Appendix C: STI 5-Year Network Assessment

The following document was compiled by STI under contract with the District to satisfy federal requirements under 40 CFR 58.10 (d). The opinions contained herein do not necessarily reflect the opinions of the District. Please see pages 34 – 36 of the District's 2010 Air Monitoring Network Plan for more information.

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Sonoma Technology, Inc.
Air Quality Research and Innovative Solutions

AMBIENT AIR QUALITY MONITORING NETWORK ASSESSMENT FOR THE SAN JOAQUIN VALLEY

Final Report
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TABLE OF CONTENTS

Section **Page**

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES

Table **Page**

1. INTRODUCTION

The U.S. Environmental Protection Agency (EPA) recently drafted the National Ambient Air Monitoring Strategy (NAAMS). The purpose of NAAMS is to optimize U.S. air monitoring networks to achieve (with limited resources) the best possible scientific value while continuing to protect public and environmental health. An important element of NAAMS is a plan for periodic network assessments at national, regional, and local levels. A network assessment includes (1) evaluation of air monitoring objectives and budget, (2) evaluation of a monitoring network's effectiveness and efficiency relative to its objectives and cost, and (3) recommendations for network reconfigurations and improvements. The EPA expects that a multi-level network assessment will be conducted every five years, with the first to be completed by the end of 2010 (U.S. Environmental Protection Agency, 2005, 2006).

To proactively meet the EPA's network assessment mandate, the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) contracted with Sonoma Technology, Inc. (STI) to perform an assessment of the SJVUAPCD air and meteorological monitoring networks. This report contains the findings and recommendations resulting from the network assessment.

1.1 BACKGROUND

Ambient air monitoring objectives and demographic characteristics change over time, thus motivating air quality agencies to re-evaluate and reconfigure their monitoring networks. Several factors have prompted the changes in air monitoring objectives: improvement in air quality, changes in population distribution and behaviors, changes in air quality mandates, and advancements in the scientific understanding of air quality phenomena. As a result of these changes, air monitoring networks in some regions may have unnecessary or redundant monitors or ineffective monitoring locations for some pollutants, while other regions may lack necessary monitors altogether.

Changes in $PM_{2.5}$ and ozone National Ambient Air Quality Standards (NAAQS) and other air monitoring objectives are motivating air quality agencies to refocus their monitoring resources on pollutants of emerging interest or persistent challenge, such as particulate matter less than 2.5 microns ($PM_{2.5}$), air toxics, and ground-level ozone and precursor compounds. In addition, agencies are interested in designing networks to protect today's population and environment while maintaining a focus on long-term air quality trends. Moreover, agencies are using new air monitoring technologies and developing an improved scientific understanding of air quality issues.

Monitoring networks should be designed and configured to address multiple, interrelated air quality issues (i.e., a multipollutant approach) and to support other types of air quality studies (e.g., photochemical modeling and emission inventory assessments). Reconfiguring air monitoring networks to help meet the needs of current air quality research and issues will enhance their value to stakeholders, scientists, and the general public. Performing an air monitoring network assessment involves re-evaluation of the objectives and budget for air monitoring, evaluating a network's effectiveness and efficiency relative to its objectives and costs, and making recommendations for network reconfigurations and improvements. The assessment performed by STI did not take into account the operational costs associated with the monitoring network; the SJVUAPCD will evaluate the resources and costs of the assessment.

1.2 NETWORK ASSESSMENT OBJECTIVES

The SJV (San Joaquin Valley) is an area with rich agricultural resources, abundant industry, and a growing population. The SJVUAPCD seeks to ensure that its monitoring network is (1) capable of effectively characterizing air quality and meteorology in the region and (2) meeting its monitoring objectives. The objectives of the SJVUAPCD air monitoring network are to assure compliance with NAAQS, determine control strategy effectiveness, support air quality forecasting, provide information that helps inform the public of air quality conditions and potential public health risks, and support air quality modeling.

The objectives of this network assessment are to identify and recommend adjustments to the SJVUAPCD criteria pollutant, Photochemical Assessment Monitoring Stations (PAMS), and meteorological monitoring network that may be needed to address air quality improvements, emissions reductions, population increases, and the five-year network assessment requirements set forth by the EPA (40 CFR 58.10). These requirements address questions as to whether sites are appropriately located to

- determine the highest criteria pollutant concentrations expected to occur in the area covered by the network,
- measure typical concentrations in areas of high population density,
- determine the impact of significant sources or source categories on air quality
- determine general background concentration levels,
- determine the extent of regional pollutant transport among populated areas , and
- measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts to support secondary standards

Additionally, a network assessment can identify potentially redundant sites, areas where new sites may be needed, and new technologies that may add value to the air monitoring network.

1.3 NETWORK OVERVIEW

The SJVUAPCD air monitoring network is a rich network that measures a variety of pollutants and has a long record of criteria pollutant data. **Figure 1-1** shows a map of the SJVUAPCD's air monitoring network and the general network assessment study domain (gray boundary). In addition to the sites operated by the SJVUAPCD, several other sites located in the SJV are operated by other jurisdictions (i.e., the California Air Resources Board─CARB) that are located both within the study domain and along the periphery of the domain. The SJVUAPCD is planning to deploy five additional sites in the near future. The map in Figure 1-1 shows the sites operated by the SJVUAPCD (blue circles), the planned sites (stars), sites located in the SJV that are operated by the CARB (gray squares), and sites that are operated by the National Park Service (NPS) (orange squares).

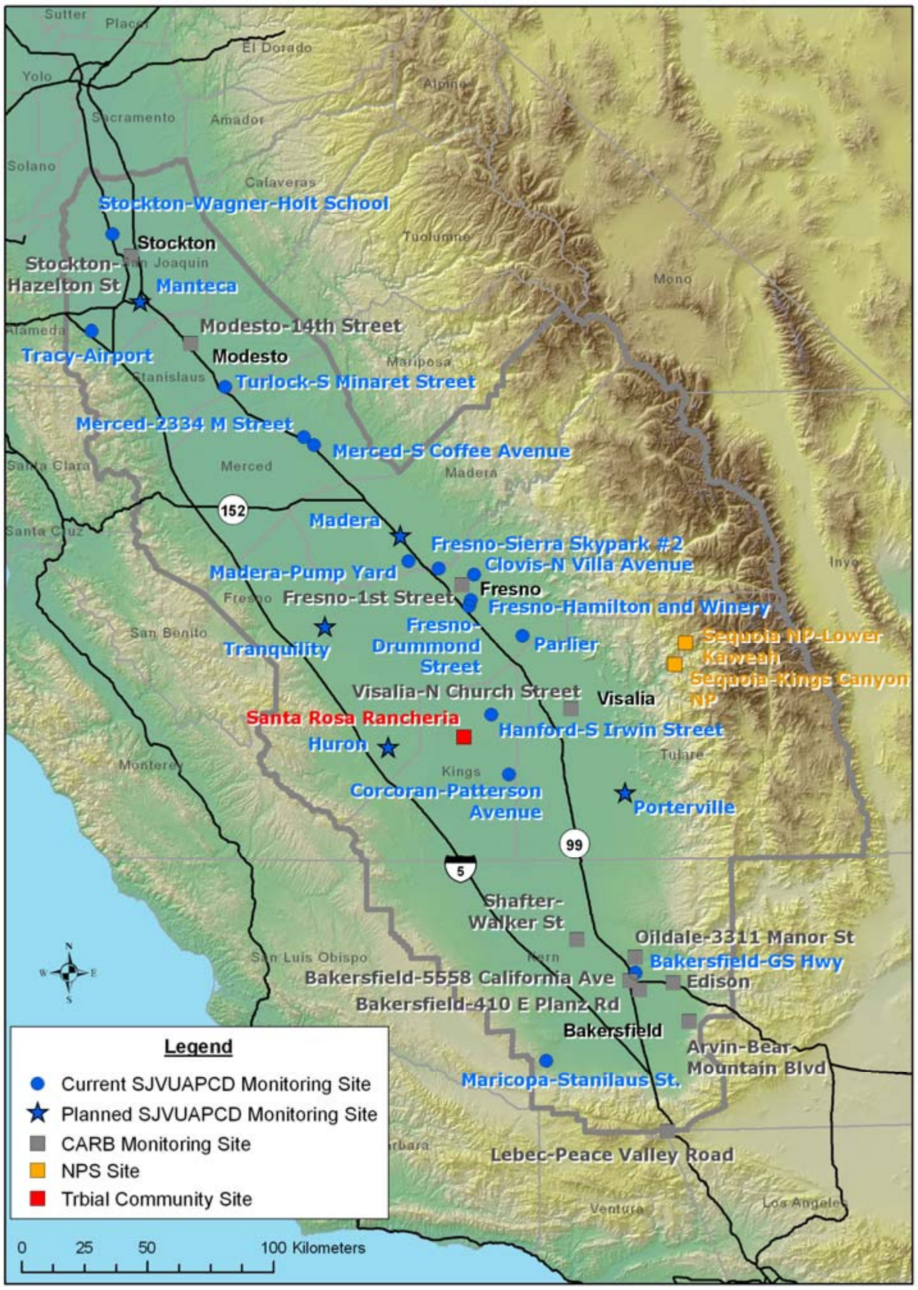


Figure 1-1. Map of the network assessment study domain and the air monitoring sites located in the SJV, including planned sites.

The SJV is geographically large and comprises eight counties with a combined area of approximately 27,000 square miles (Umbach, 2005). Overall, the SJV monitoring network is modest, with several agencies operating sites within the valley. The SJVUAPCD's monitoring network, that is, those sites currently operated by the SJVUAPCD, consists of 10 ozone monitors, 10 NO_2 monitors, 5 $PM_{2.5}$ monitors, 8 PM_{10} monitors, 5 CO monitors, and 6 PAMS monitoring sites that collect ozone, oxides of nitrogen (NO_x and NO_y), and volatile organic compound (VOC) data. The overall focus of air quality monitoring in the SJV is to capture representative population exposure pollutant concentrations. Most of the sites in the SJV are located in densely populated areas and areas of high urban emissions. Appendix A includes a table and more detailed information about the SJVUAPCD-operated sites.

1.4 GUIDE TO THIS REPORT

The remaining sections of this report detail the analysis approach, findings, and recommendations from this network assessment. Section 2 includes a discussion of the technical approach and findings of the air monitoring network assessment. The technical approach and findings of the meteorological network assessment are discussed in Section 3. Section 4 contains a synthesized discussion of findings, conclusions, and recommendations for adjustments to the network.

2. TECHNICAL APPROACH AND FINDINGS OF THE AIR MONITORING NETWORK ASSESSMENT

The overall technical approach for conducting the network assessment of the SJVUAPCD's criteria pollutant, PAMS, and meteorological monitoring network was divided into two main tasks: (1) performing the air monitoring network assessment and (2) performing the meteorological network assessment. The results of the air monitoring and meteorological analyses were first viewed independently and then synthesized and viewed holistically. Recommendations for adjustments to the overall network were then developed.

Table 2-1 lists the network assessment analyses that were used to address the monitoring objectives (as discussed in Section 1.2) and the following questions:

- Which sites provide the most value in terms of the number of pollutants measured, the length of data record, and data quality?
- Are sites appropriately located to determine the highest pollutant concentrations expected to occur in the area covered by the network?
- Are sites appropriately located to measure typical pollutant concentrations in areas of high population density?
- Are sites appropriately located to determine the impact of significant sources or source categories on air quality?
- Are sites appropriately located to determine general background concentration levels?
- Are sites appropriately located to determine the extent of regional pollutant transport among populated areas?
- Are sites appropriately located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts and to support secondary standards?
- Are there potentially redundant sites in the network?
- Are there areas where new sites may be needed?
- Are there new technologies that may add value to the air monitoring network?

The analyses listed in Table 2-1 are a subset of the analysis methods prescribed in the EPA's *Ambient Air Monitoring Network Assessment Guidance Document* (Raffuse et al., 2007).

Table 2-1. Summary of the analyses performed and the monitoring objectives or questions addressed.

	Site-by-Site Analyses							**Bottom-up Analyses**		
Objective or Question	**Data Above the Method Detection Limit (MDL)**	**Number of Parameters Measured**	**Length of Trend Record**	**Measured Concentrations**	**Deviation from NAAQS**	**Wind Rose Analyses**	**Correlation Analyses**	**Area-Served**	**Population Density/ Population Served/ Population Change**	**Emissions Served**
Which sites provide the most value in terms of the number of pollutants measured, the length of data record, and data quality?	X	X	X							
Are sites appropriately located to determine the highest pollutant concentrations expected to occur in the area covered by the network?				X	X					
Are sites appropriately located to measure typical pollutant concentrations in areas of high population density?		X						X	X	
Are sites appropriately located to determine the impact of significant sources or source categories on air quality?										X
Are sites appropriately located to determine general background concentration levels?				X				X	X	X
Are sites appropriately located to determine the extent of regional pollutant transport among populated areas?				X				X	X	
Are sites appropriately located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts and to support secondary standards?								X		
Are there potentially redundant sites in the network?							X	X	X	
Are there areas where new sites may be needed?								X	X	X
Is the meteorological network adequate for characterizing regional surface and upper-air meteorology?		X				X	X			

A network assessment comprises several analysis methods that address specific objectives. The overall approach when performing each analysis is to rank the sites highest that best meet the specified objectives for each analysis technique. It is important to note that no one analysis stands alone and that the results are synthesized, evaluated, and viewed in the context of the overall monitoring objectives. Recommendations are then made on the basis of the synthesized results. The remainder of this section presents a summary of key findings (Section 2.1), a discussion of the technical approach and findings for the site-by-site and bottom-up analyses for the criteria pollutant network (Section 2.2), and a discussion of the PAMS network (Section 2.3).

2.1 SUMMARY OF KEY FINDINGS FROM THE AIR MONITORING NETWORK ASSESSMENT

This section summarizes the key findings from the air monitoring network assessment. The sections that follow provide a more detailed discussion of the process used to arrive at the findings below. A discussion of these findings and the resulting recommendations are included in Section 4.

Criteria Pollutant Network

- Overall data completeness and percent above method detection limit (MDL) values are very good for all pollutants with the exception of CO. Data completeness is very good for CO; however, the percent above MDL values are low because CO concentrations are low in the SJV. The SJVUAPCD is currently operating low-sensitivity instruments but is planning to deploy high-sensitivity CO instruments in the future.
- Measured concentrations of ozone and $PM_{2.5}$ are high relative to the NAAQS throughout the SJV. The Tracy, Turlock, Madera, Fresno–Drummond, and Bakersfield–Golden State Highway (GSH) sites are the most valuable SJVUAPCD operated sites for determining NAAQS attainment.
- There is adequate data for examining long-term trends in ozone, $PM_{2.5}$, PM_{10}, NO_2, and PAMS species. The SJVUAPCD will be installing additional 1-hr continuous $PM_{2.5}$ sites in the near future.
- The sites operated by the CARB are important sites for monitoring criteria pollutants in the SJV. The results of this network assessment assume that the CARB will continue to operate these sites and that data of high quality will be routinely available. If one (or more) of these sites is discontinued, the SJVUAPCD should implement comparable measurements at or near the discontinued sites.
- The SJVUAPCD is planning to deploy two additional ozone monitors in Tranquility and Porterville. Analyses indicate that these sites will fill existing gaps in the network.

- The SJVUAPCD is planning to deploy two additional $PM_{2.5}$ 1-hr continuous monitors in Manteca and Madera. Analyses indicate that these sites will fill existing gaps in the network for monitoring population exposure.
- The SJVUAPCD is planning to deploy a PM_{10} 1-hr site in Madera. Analyses indicate that this site will fill an existing gap in the network along the north-south central corridor of the SJV. However, there are no PM_{10} 1-hr sites in the eastern and western regions of the SJV.
- Two main areas within the SJV may warrant additional criteria pollutant monitoring sites: (1) the region to the west of Merced (Los Banos area), and (2) the region to the northeast of Clovis. Unmonitored areas more than 50 km away from existing monitors are a concern. Unless the SJVUAPCD has special study data indicating low spatial variability in pollutant concentrations in the areas that lack monitors, additional sites in unmonitored regions should be considered. The SJVUAPCD should consider adding two criteria sites in the region west of Merced (Los Banos area) and in the region northeast of Clovis, where there appear to be existing gaps in the network.
- The area between Corcoran and Bakersfield may warrant an additional $PM_{2.5}$ 1-hr continuous monitoring site based on population density and PM emissions levels.
- Potential improvements to the PM_{10} 1-hr continuous network might include adding PM_{10} monitors at the planned $PM_{2.5}$ 1-hr sites (i.e., Huron, Manteca, and Tranquility) and/or augmenting the 24-hr PM_{10} monitors with 1-hr PM_{10} monitors at existing sites.
- A gap exists in the NO_2 network along the western side of the SJV. Deploying an NO_2 monitor at the planned Tranquility ozone site could help fill this gap.
- Four CO monitors are located in the greater Fresno area (three of which are run by the SJVUAPCD). In addition to adding a trace CO monitor at the Clovis site, relocating one or two of the CO sites in Fresno to area(s) outside Fresno could be beneficial, as there may be some redundancy in CO sites in the Fresno area.

PAMS Network

- The quality of the PAMS VOC data in the SJV is generally poor. The data quality assessment indicated that MDLs throughout the region are high. Despite high observed concentrations, more than 50% of VOC measurements are reported below the MDL at PAMS sites in the SJV.
- Based on an analysis of maximum concentrations, the SJV reported some of the highest precursor emission concentrations in the United States (McCarthy et al., 2008).
- All of the PAMS sites in the SJV have a data record that is suitable for trends analysis.
- Based on maximum concentration analyses for ozone, the Parlier PAMS site (a Type 3 site), generally does not appear to be measuring maximum ozone

concentrations. The SJVUAPCD should consider relocating this site to the foothill region east of Fresno or changing the site designation to Type 2 to better reflect measured concentrations.

2.2 TECHNICAL APPROACH AND FINDINGS FOR THE AIR MONITORING NETWORK ASSESSMENT

This section contains a description of the technical approach and findings of the site-by-site and bottom-up analyses. The site-by-site analyses focus on assessing individual sites within the network and include a determination of the number of parameters monitored; the fraction of data reported; the fraction of data above the MDL; the measured concentrations; the deviation from NAAQS; and the length of trend record at each site. While sites operated by both the SJVUAPCD and the CARB were included in the site-by-site analyses, comments and recommendations were focused on only those sites operated by the SJVUAPCD because the SJVUAPCD has direct jurisdiction and the authority to implement site-specific recommendations.

The spatial coverage analyses (bottom-up analyses) focus on the locations of sites relative to other sites within the network and include estimating the spatial representativeness of each site (area-served analysis); the population represented by each site (population-served), the growth in population around each site (population change), and the emissions represented by each site (emissions-served). The purpose of the bottom-up analyses is to identify potential gaps or redundancies in the network. Sites operated by both the SJVUAPCD, the CARB, and other agencies were considered in the bottom-up analyses to avoid recommending that a new site be placed where one may already exist.

2.2.1 Sources of Data

The following data (and sources) were acquired and used to perform the air monitoring network assessment:

- **Air quality data summaries:** Annual summary data were acquired for all sites within 20 miles of the SJV air basin from the EPA's AirData website (http://www.epa.gov/oar/data/) for 1997–2007. These data included statistical summaries for all monitor-site-method combinations. Additionally, ancillary and meta data including site locations, method codes, and sampling interval codes were acquired from the AirData website.
- **Population data:** Spatially resolved population data (block-group polygons) were acquired from the U.S. Census Bureau for the SJV for 2000 and 2007. Block-group polygon centroids, the center-point of a polygon, were mapped within a geographic information system (GIS), and population density values were calculated.

- **Emission inventory data:** The most recent gridded emissions data were collected from the CARB, and included total organic gases (TOG), NO_x, and PM emissions representative of a summer weekday in 2000.
- **PAMS data:** PAMS 2004-2006 data were acquired for the national PAMS network assessment (http://www.epa.gov/aqspubl1/annual_summary.html).

2.2.2 Number of Parameters Monitored

Air quality monitoring sites with instruments that measure many pollutants and meteorological parameters are generally more valuable than sites that measure fewer parameters, assuming that the data collected are of high or of similar quality. In addition, sites that measure several pollutants are generally more cost effective to operate. STI assessed and ranked each air quality and meteorological site by the number of parameters collected at each site. **Figure 2-1** shows the number of parameters monitored.

The PAMS sites (Madera–Pump Yard, Clovis–N. Villa Avenue, Parlier, Bakersfield–GSH, Shafter–Walker Street, and Arvin–Bear Mountain Blvd.) are valuable sites because they measure the most parameters. The Tracy Airport, Turlock–S. Minaret Street, Fresno–Sierra Skypark, and Fresno–Drummond Street sites are important SJVUAPCD sites for criteria pollutants because they measure several parameters. As previously mentioned, these conclusions are only meaningful if the data collected are complete and of good quality.

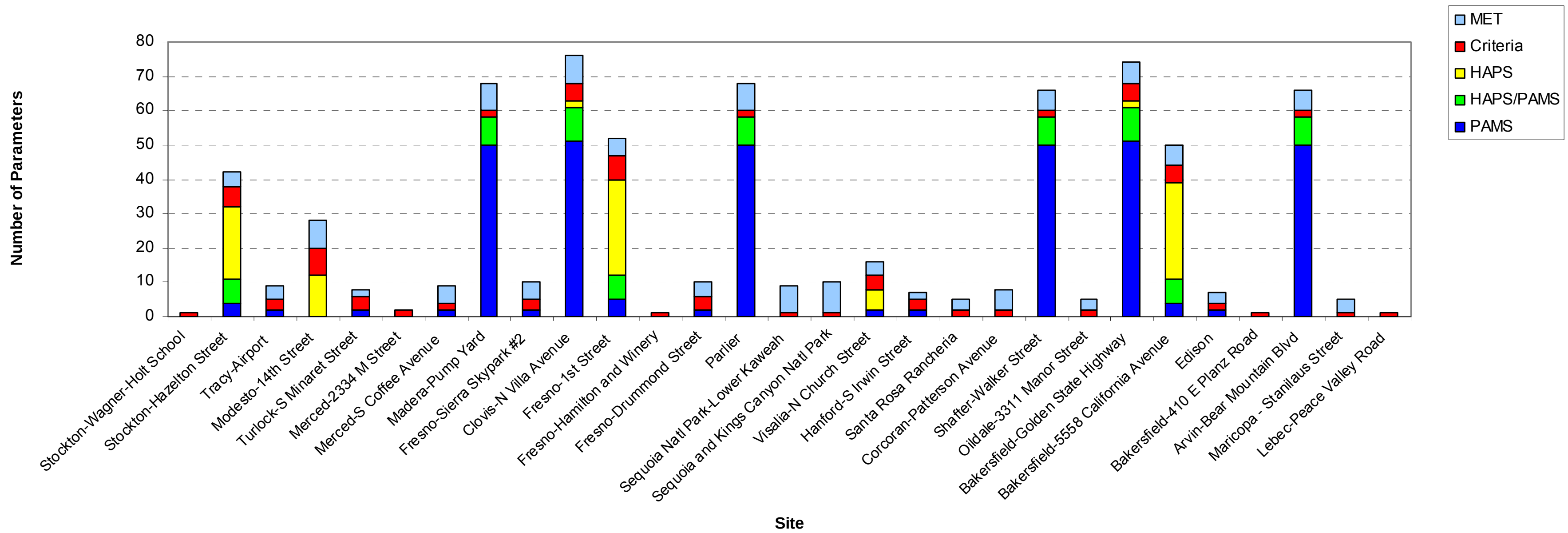


Figure 2-1. The number of parameters monitored at each site. Note that the operation of the Shafter–Walker Street and Arvin–Bear Mountain Blvd sites is shared between the SJVUAPCD and the CARB. The SJVUAPCD operates the PAMS VOC monitors at these sites. The height of each bar represents the total number of parameters monitored at that site. The bars are subdivided and color-coded by type (meteorological, criteria, hazardous air pollutants [HAPs], and PAMS). Sites are ordered from left to right along the x-axis corresponding to their north to south geographic locations in the SJV.

2.2.3 Data Completeness, Data Above MDL, Measured Concentrations, and Deviation from NAAQS Analyses

This section discusses the approach and results of several site-by-site analyses including data completeness, percent above the MDL, measured concentrations, and the deviation from NAAQS.

Data Completeness

Sites with complete data sets are more valuable for air quality analysis and tracking than sites that have long periods of missing or invalidated data. Data completeness is a measure of the number of actual data records collected and reported at a monitoring site relative to the number of expected data records based on the sampling interval and frequency for a given parameter or pollutant. Data completeness is calculated by dividing the actual number of data records reported by the expected number of data records. The expected number of data records for a given pollutant is based on the length of monitoring season and the sampling frequency. For example, a continuous ozone monitor operating year-round would be expected to have 8,760 data records for one year of operation (1 measurement per hour x 24 hours x 365 days per year = 8,760).

Data completeness is presented as the percent of data records reported taking into account the sampling frequency. The EPA recommends that data completeness of 85% is considered good for a given site, indicating that there are enough data to perform robust data analyses assuming the data are of high quality (Raffuse et al., 2007). Because of instrument calibration, the percentages for data completeness will generally be a few percent (3-5%) below 100 depending on how frequently an instrument is calibrated.

Percent Above the MDL

The MDL is a value at which a measured concentration is considered statistically distinguishable from zero. An assessment of the percent of data above the MDL is performed to identify the number of samples in a data set that are considered to have concentration values statistically distinguishable from zero. While samples below the MDL can be used for some purposes, such as stating that a concentration is below the MDL for comparison to NAAQS, they are not as useful for quantifying ambient concentrations, trends analysis, and/or air quality model validation. The percent above the MDL analysis provides an indicator of data quality and the usefulness of the data collected for performing air quality analyses.

Measured Concentrations

Measured concentrations analysis identifies sites that consistently measure high pollutant concentrations. For this analysis, the average and maximum concentration values were examined. Results of this analysis were used to determine whether each site is meeting its objective(s). For example, if the objective of a particular site is to measure high pollutant concentrations but that site routinely measures low concentrations, then we may conclude that the objective of the site should be changed or the site should be relocated to an area of high pollutant concentrations in order to meet its objective.

Deviation from NAAQS

The deviation from NAAQS analysis indicates sites that are important for monitoring NAAQS compliance. This analysis was not designed to determine attainment status but to provide an estimate of whether concentrations observed at a particular site are close to the NAAQS. Sites routinely measuring concentration values close to the NAAQS are considered important for meeting the monitoring objective of determining NAAQS attainment. The deviation from the NAAQS is the difference between the pollutant-specific design value observed at the site and the NAAQS compliance value (e.g., 1-hr, 8-hr, 4^{th} highest maximum value, etc.). Small changes in measured pollutant concentrations can result in values above or below the NAAQS. In some cases, when information to determine the design value was not available, comparisons of the annual average or maximum pollutant concentrations were made. The deviation from NAAQS calculations presented here are not meant to be attainment calculations but general comparisons against the NAAQS to identify sites having measured values near (within 15% of) the NAAQS.

Summary and Discussion of Results

Tables 2-2 through 2-9 include a summary and discussion of the results of the analyses for data completeness, percent above MDL, measured concentrations, and deviation from NAAQS for ozone, nitrogen dioxide, PM_{10}, $PM_{2.5}$, and carbon monoxide. Tables 2-2 through 2-9 include all sites in the SJV. Sites in bold are operated by the SJVUAPCD. In Tables 2-2 through 2-9, the cells shaded blue indicate the following:

- Percent complete – sites with a percent complete value less than 85%
- Percent above MDL – sites with a percent above MDL value less than 85%
- Deviation from NAAQS – sites with a deviation from NAAQS value that is within 15% of the NAAQS for the pollutant indicated.

Overall, data completeness for 1-hr ozone is very good (Table 2-2). All sites with the exception of Maricopa have data completeness of 90% or greater. Overall, the percent above MDL results are good. Several sites (indicated in blue in Table 2-2) have percent above MDL values that are less than 85%; however, most of those values are greater than 80%. The Fresno–Drummond Street and Bakersfield–GSH sites have percent above MDL values of 78% and 74% (respectively). The values at these sites are worth noting because these sites are in urban areas and may likely measure chemically titrated ozone concentrations, which could account for the lower percent above MDL values for these two sites.

Measured concentrations results for ozone indicate that all sites measure high ozone concentrations relative to the NAAQS for both the hourly and 8-hr average time intervals. Bakersfield–GSH, Clovis–N. Villa Avenue, Parlier, and Fresno–Drummond Street are particularly valuable sites for measuring high concentrations.

The deviation from NAAQS analysis for ozone (Table 2-3) indicates that Turlock–S. Minaret Street, Madera–Pump Yard, Tracy–Airport, Fresno–Drummond Street, and Bakersfield–GSH are particularly important sites for determining NAAQS attainment because they measure concentration values that are close to (within 10%) the 8-hr ozone NAAQS. None of the 3-yr averages of the 4th highest 8-hr daily maximum measured concentrations were below the NAAQS for the SJVUAPCD-operated sites.

Overall, the data completeness and percent above MDL values for NO_2 are very good (Table 2-4). The measured concentrations and deviation from NAAQS analyses indicate that average NO_2 concentrations are well below the standard at all sites.

Table 2-2. Summary of data completeness, percent above MDL, and measured concentrations analyses for 1-hr ozone data.

Site Name	% Complete	% Above MDL	Maximum Value
Madera-Pump Yard	**95**	**83**	**91**
Fresno-Drummond Street	**94**	**78**	**110**
Turlock-S Minaret Street	**95**	**80**	**101**
Tracy-Airport	**94**	**94**	**97**
Bakersfield-Golden State Highway	**94**	**74**	**127**
Fresno-Sierra Skypark #2	**95**	**85**	**105**
Merced-S Coffee Avenue	**95**	**84**	**105**
Parlier	**93**	**88**	**113**
Hanford-S Irwin Street	**78**	**83**	**102**
Clovis-N Villa Avenue	**91**	**84**	**121**
Maricopa-Stanislaus Street	**77**	**100**	**97**
Fresno-1st Street	81	100	107
Edison	94	100	114
Bakersfield-5558 California Avenue	77	100	97
Oildale-3311 Manor Street	96	100	99
Arvin-Bear Mountain Blvd	100	100	120
Shafter-Walker Street	79	100	93
Santa Rosa Rancheria	86	100	100
Lebec-Peace Valley Road	99	98	74
Stockton-Hazelton Street	78	93	89
Modesto-14th Street	87	100	91
Sequoia Natl Park-Lower Kaweah	100	100	101
Sequoia and Kings Canyon Natl Park	100	100	109
Visalia-N Church Street	81	100	100

Table reflects data for 2007.
Concentration data are reported in units of ppb.
Ozone MDL = 5 ppb.
Maximum value equals the 1-hr annual maximum.
Deviation from NAAQS = maximum value at each site -75 ppb.
Cells highlighted in blue in the % Above MDL column indicate sites with fewer than 85% of data reported above the MDL.

Table 2-3. Summary of data completeness, measured concentrations, and deviation from NAAQS analyses for 8-hr average ozone data.

Site Name	% Complete	Maximum Value	4th Highest Value	Deviation From NAAQS
Turlock-S Minaret Street	**99**	**88**	**75**	**0**
Madera-Pump Yard	**99**	**83**	**77**	**2**
Tracy-Airport	**98**	**83**	**79**	**4**
Fresno-Drummond Street	**98**	**92**	**79**	**4**
Bakersfield-Golden State Highway	**99**	**102**	**80**	**5**
Merced-S Coffee Avenue	**100**	**96**	**87**	**12**
Fresno-Sierra Skypark #2	**99**	**96**	**88**	**13**
Parlier	**98**	**96**	**90**	**15**
Hanford-S Irwin Street	**82**	**91**	**80**	**5**
Clovis-N Villa Avenue	**95**	**101**	**92**	**17**
Maricopa-Stanislaus Street	**81**	**90**	**86**	**11**
Fresno-1st Street	99	94	85	10
Edison	99	93	75	0
Bakersfield-5558 California Avenue	99	85	63	-12
Oildale-3311 Manor Street	98	90	86	11
Arvin-Bear Mountain Blvd	98	102	87	12
Shafter-Walker Street	98	83	76	1
Santa Rosa Rancheria	99	88	83	8
Lebec-Peace Valley Road	23	63	91	16
Stockton-Hazelton Street	99	75	94	19
Modesto-14th Street	100	76	99	24
Sequoia Natl Park-Lower Kaweah	99	91	90	15
Sequoia and Kings Canyon Natl Park	68	99	88	13
Visalia-N Church Street	99	86	102	27

Table reflects data for 2007.
Concentration data are reported in units of ppb.
Maximum value equals the 8-hr average annual maximum.
Deviation from NAAQS = 4th highest value at each site -75 ppb.
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.

Table 2-4. Summary of data completeness, percent above MDL, measured concentrations, and deviation from NAAQS analyses for NO_2.

Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation From NAAQS
Tracy-Airport	**91**	**100**	**45**	**9.4**	**-43.6**
Turlock-S Minaret Street	**94**	**100**	**53**	**11.8**	**-41.2**
Merced-S Coffee Avenue	**94**	**100**	**50**	**9.4**	**-43.6**
Madera-Pump Yard	**93**	**100**	**47**	**10.1**	**-42.9**
Fresno-Sierra Skypark #2	**92**	**99**	**56**	**10.1**	**-42.9**
Clovis-N Villa Avenue	**91**	**100**	**64**	**14.8**	**-38.2**
Fresno-Drummond Street	**91**	**100**	**67**	**16.2**	**-36.8**
Parlier	**94**	**100**	**55**	**10.9**	**-42.1**
Hanford-S Irwin Street	**78**	**100**	**58**	**11**	**-42**
Bakersfield-Golden State Highway	**93**	**100**	**73**	**19.7**	**-33.3**
Fresno-1st Street	95	100	86	16.6	-36.4
Edison	95	99	48	9.7	-43.3
Bakersfield-5558 California Avenue	94	100	72	17.2	-35.8
Arvin-Bear Mountain Blvd	94	100	52	8.5	-44.5
Shafter-Walker Street	95	100	101	14.3	-38.7
Stockton-Hazelton Street	94	100	70	16.4	-36.6
Visalia-N Church Street	95	100	71	14.8	-38.2

Table reflects data for 2007.
Nitrogen dioxide MDL = 1 ppb.
Maximum value equals the 1-hr annual maximum concentration.
Annual average NO_2 NAAQS = 53 ppb.
Concentration data are reported in units of ppb.

Data completeness and percent above MDL are very good for PM_{10} (Tables 2-5 and 2-6). The measured concentrations and deviation from NAAQS analyses indicate that daily maximum concentrations are well below the NAAQS at all sites. The highest observed maximum concentration of FRM PM_{10} occurred at Bakersfield–GSH; it is the most valuable site for determining NAAQS attainment. The maximum 1-hr PM_{10} concentrations are highest at Corcoran and Bakersfield–GSH, and these sites are the most valuable for determining NAAQS attainment. Data analyses should be performed to understand the relationship between the 1-hr and 24-hr PM_{10} data, and to specifically examine the discrepancy between the maximum values in the 24-hr versus 1-hr data at Bakersfield–GSH.

Table 2-5. Summary of results of data completeness, percent above MDL, measured concentrations, and deviation from NAAQS analyses for Federal Reference Method (FRM) PM_{10} measurements.

Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation from NAAQS
Stockton-Wagner-Holt School	**97**	**100**	**65**	**24**	**-85**
Turlock-S Minaret Street	**98**	**100**	**77**	**32**	**-73**
Merced-2334 M Street	**97**	**100**	**69**	**30**	**-81**
Clovis-N Villa Avenue	**90**	**100**	**111**	**34**	**-39**
Fresno-Drummond Street	**97**	**100**	**93**	**38**	**-57**
Corcoran-Patterson Avenue	**98**	**100**	**124**	**46**	**-26**
Bakersfield-Golden State Highway	**97**	**100**	**135**	**55**	**-15**
Hanford	**97**	**100**	**100**	**44**	**-50**
Fresno-1st Street	98	100	102	32	-48
Bakersfield-5558 California Avenue	97	100	118	49	-32
Oildale-3311 Manor Street	99	100	108	45	-42
Santa Rosa Rancheria	97	100	120	45	-30
Stockton-Hazelton Street	98	100	75	28	-75
Modesto-14th Street	97	100	87	28	-63
Visalia-N Church Street	98	100	99	42	-51
Mammoth Lakes Gateway	95	99	56	15	-94

Table reflects data for 2007.
Concentration data are reported in units of $\mu g/m^3$.
PM_{10} MDL = 4 $\mu g/m^3$ for 24-hr filter-based monitors.
NAAQS = 150 $\mu g/m^3$.
Maximum value equals the annual daily maximum concentration.
Deviation from NAAQS = 150 $\mu g/m^3$, the maximum value at each site.
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.

Table 2-6. Summary of data completeness, measured concentrations, and deviation from NAAQS analyses for 1-hr continuous PM_{10}.

Site Name	% Complete	Maximum Value	Mean Value	Deviation from NAAQS
Tracy-Airport	97	75	20	-75
Corcoran-Patterson Avenue	98	128	39	-22
Bakersfield-Golden State Highway	100	172	43	22

Table reflects data for 2007.
Concentration data are reported in units of $\mu g/m^3$.
PM_{10} MDL = -50 $\mu g/m^3$ for continuous monitors.
Deviation from NAAQS = 150 $\mu g/m^3$, the maximum value at each site.
Maximum value equals the 24-hr maximum value calculated from 1-hr data.
NAAQS = 150 $\mu g/m^3$.
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.
There is a 1-hr continuous PM_{10} site at Fresno 1st Street; however, the data from this site are not available in EPA's Air Quality System (AQS).

All FRM $PM_{2.5}$ 24-hr filter sites indicate good data completeness and percent above MDL (Table 2-7). The measured concentrations and deviation from NAAQS analyses indicate that the concentrations are higher than the annual standard at all sites. The Merced site is a valuable site for determining NAAQS attainment. Sites with $PM_{2.5}$ continuous measurements have good data completeness (Table 2-8). The measured concentrations and deviation from NAAQS analyses indicate that annual concentrations are higher than the standard at all sites with the exception of Tracy–Airport, which is slightly below the standard.

Maximum 1-hr $PM_{2.5}$ concentrations are high and do not appear in the 24-hr data. It appears that an exceptional event (the Fourth of July) was flagged in the 24-hr data but was not flagged in the 1-hr data. Both the Tracy and Turlock sites appear to be the most valuable for determining NAAQS attainment; however, note again, that the Deviation from NAAQS analysis is not meant to determine NAAQS compliance but to identify those sites that routinely measure concentrations close to the NAAQS. It should also be noted that it is not appropriate to use 1-hr FRM data to determine NAAQS attainment.

Table 2-7. Summary of data completeness, percent above MDL, measured concentrations, and deviation from NAAQS analyses for FRM $PM_{2.5}$ measurements.

Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation from NAAQS
Merced-2334 M Street	**98**	**100**	**81.6**	**17.7**	**2.7**
Clovis-N Villa Avenue	**92**	**100**	**64.7**	**19.2**	**4.2**
Fresno-Hamilton and Winery	**98**	**100**	**65.1**	**19.5**	**4.5**
Corcoran-Patterson Avenue	**91**	**100**	**75**	**20.9**	**5.9**
Bakersfield-Golden State Highway	**88**	**100**	**86.6**	**22.6**	**7.6**
Bakersfield-410 E Planz Road	89	100	91	21.5	6.5
Bakersfield-5558 California Avenue	75	100	86	21.9	6.9
Fresno-1st Street	97	100	104	18.8	3.8
Modesto-14th Street	99	100	64	14.8	-0.2
Stockton-Hazelton Street	99	100	52	12.8	-2.2
Visalia-N Church Street	96	100	71	19.9	4.9

Table reflects data for 2007.
Concentration data are reported in units of $\mu g/m^3$.
$PM_{2.5}$ MDL = 2 $\mu g/m^3$ for 24-hr filter-based monitors.
NAAQS = 15 $\mu g/m^3$.
Maximum value equals the maximum daily average value.
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.

Table 2-8. Summary of data completeness, percent above MDL, measured concentrations, and deviation from NAAQS analyses for 1-hr continuous $PM_{2.5}$ measurements.

Site Name	% Complete	% Above MDL	Maximum Value	Mean Value	Deviation from NAAQS
Tracy-Airport	**87**	**100**	**142**	**12.6**	**-2.5**
Turlock-S Minaret Street	**100**	**100**	**1001**	**17.7**	**2.7**
Clovis-N Villa Avenue	**95**	**100**	**759**	**25.1**	**10.1**
Corcoran-Patterson Avenue	**97**	**100**	**980**	**21.7**	**6.7**
Bakersfield-Golden State Highway	**98**	**100**	**1000**	**25.1**	**10.1**
Bakersfield-5558 California Avenue	97	100	259	22.1	7.1
Fresno-1st Street	98	100	537	22.4	7.4
Lebec-Peace Valley Road	98	100	64	7.2	-7.7
Modesto-14th Street	99	100	277	16	1
Stockton-Hazelton Street	99	100	84	13.5	-1.5
Visalia-N Church Street	98	100	168	22.3	7.3

Table reflects data for 2007.
Concentration data are reported in units of µg/m^3.
$PM_{2.5}$ MDL = 2 µg/m^3 for 24-hr filter-based monitors.
NAAQS = 15 µg/m^3.
Maximum value equals the 24-hr maximum value calculated from 1-hr data.
Cells highlighted in blue in the Deviation from NAAQS column indicate sites that are valuable for determining NAAQS attainment.

Data completeness for CO is very good at all sites; however, percent above MDL at all sites is less than 50% (Table 2-9). This is due to the low CO concentrations in the SJV relative to the NAAQS and the need for higher sensitivity instruments to achieve a higher percentage of data above MDL. The SJVUAPCD is planning to install high-sensitivity CO instruments in the future. These instruments will enhance the assessment of population exposure to CO.

Table 2-9. Summary of data completeness, percent above MDL, measured concentrations, and deviation from NAAQS analyses for 8-hr CO measurements.

Site Name	% Complete	% Above MDL	Maximum Value	Deviation From NAAQS
Turlock-S Minaret Street	**100**	**21**	**1.7**	**-7.3**
Fresno-Sierra Skypark #2	**97**	**15**	**1.4**	**-7.6**
Clovis-N Villa Avenue	**97**	**35**	**1.8**	**-7.2**
Fresno-Drummond Street	**99**	**28**	**2.4**	**-6.6**
Bakersfield-Golden State Highway	**98**	**48**	**2**	**-7**
Fresno-1st Street	99	14	2.6	-6.4
Stockton-Hazelton Street	98	20	2.3	-6.7
Modesto-14th Street	98	15	3.2	-5.8

Table reflects data for 2007
Concentration data are reported in units of ppm.
CO MDL = 0.5 ppm
NAAQS 8-hr = 9 ppm
Deviation from NAAQS = 9 ppm – maximum value
Cells highlighted in blue in the % Above MDL column indicate values that are below 85%.

Concentrations of SO_2 in the SJV are currently below the standard and have not exceeded the standard in the past 10 years (San Joaquin Valley Air Pollution Control District, 2008). Therefore, the SJVUAPCD does not currently operate any SO_2 sites.

Toxics monitoring in the SJV is conducted by the CARB at sites in Bakersfield, Fresno, and Stockton. The SJVUAPCD operates several PAMS sites that measure selected toxics compounds. The SJVUAPCD PAMS network assessment is discussed in Section 2.3. There are currently no airborne lead monitoring sites operated by the SJVUAPCD.

2.2.4 Length of Trend Record Analysis

Monitors that have a long historical data record are valuable for tracking pollutant trends and control strategy effectiveness. The length of trend record analysis identifies those sites that have sufficient data records to support pollutant trends analysis. For this analysis, the number of years of data collection was summed by site and pollutant. **Table 2-10** shows the trend length by site and pollutant.

Table 2-10. Summary of length of trend record analysis results by site and pollutant. The numbers in the table represent the number of years of data collected at each site. Sites for which there are five or more years of data are highlighted in green. Sites for which there are more than 10 years of data are marked “10+”. Sites in bold are operated by the SJVUAPCD.

Site Name	Ozone	1-hr PM10	24-hr PM10	1-hr PM2.5	24-hr PM2.5	NO2	CO	PAMS
Stockton-Wagner-Holt School	0	0	10+	0	0	0	0	0
Stockton-Hazelton Street	10+	9	10+	3	9	10+	10+	0
Tracy-Airport	2	2	0	1	0	2	0	0
Modesto-14th Street	10+	5	10	6	9	9	10+	0
Turlock-S Minaret Street	10+	0	10+	1	0	10+	10+	0
Merced-2334 M Street	0	0	9	0	9	0	0	0
Merced-S Coffee Avenue	10+	0	0	0	0	10+	0	0
Madera-Pump Yard	10+	0	0	0	0	10+	0	10+
Fresno-Sierra Skypark	10+	0	0	0	0	10+	10+	0
Clovis-N Villa Avenue	10+	0	10+	1	9	10+	10+	10+
Fresno-1st Street	10+	0	10+	6	9	10+	10+	5
Fresno-Hamilton and Winery	0	0	0	0	8	0	0	0
Fresno-Drummond Street	10+	0	10+	0	0	10+	10+	0
Parlier	10+	0	0	0	0	10+	0	10+
Sequoia Natl Park-Lower Kaweah	10+	0	0	0	0	0	0	0
Sequoia and Kings Canyon Natl Park	9	0	0	0	0	0	0	0
Visalia-N Church Street	10+	0	10+	6	9	10+	9	0
Visalia Airport	0	0	0	0	0	0	0	0
Santa Rosa Rancheria	2	0	2	0	0	0	0	0
Corcoran-Patterson Avenue	0	2	10+	1	9	0	0	0
Shafter-Walker Street	10+	0	0	0	0	10+	0	10
Oildale-3311 Manor Street	10+	0	10+	0	0	9	0	0
Bakersfield-Golden State Highway	10+	2	10+	1	9	10+	10+	10+
Bakersfield-5558 California Avenue	10+	6	10+	6	9	10+	9	0
Edison	10+	0	0	0	0	10+	0	0
Bakersfield-410 E Planz Road	0	0	0	0	8	0	0	0
Arvin-Bear Mountain Blvd	10+	0	0	0	0	10+	0	10+
Maricopa - Stanilaus Street	10+	0	0	0	0	0	0	0
Lebec-Peace Valley Road	2	0	0	1	5	0	0	0

Several sites in the SJV air basin have long data records for several parameters and are valuable for assessing pollutant trends and determining control strategy effectiveness. Most notably, the Clovis–N. Villa Avenue and Bakersfield–GSH sites have been monitoring many parameters for longer than a decade.

2.2.5 Area-Served, Population-Served, Population Change, and Emissions-Served Analyses

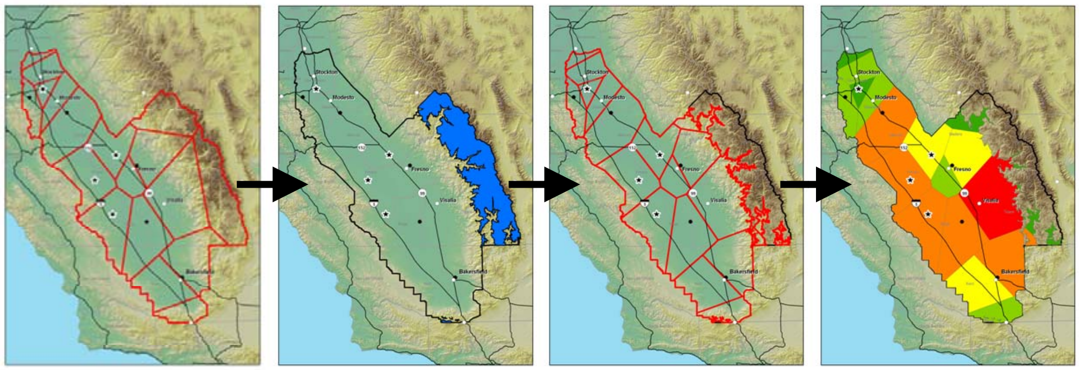
Area-served Analysis

The purpose of the area-served analysis was to estimate the spatial coverage of each monitoring site to identify potential spatial gaps or redundancies in the overall monitoring network. Performing the area-served analysis is a multi-step process. The first step in the area-served analysis was to compile a map of the air quality sites which included both the SJVUAPCD sites and other agency sites within and surrounding the district boundary, using GIS software.

The next step involved generating Thiessen polygons (also called Voronoi diagrams) within the GIS software. Thiessen polygons are applied as a standard technique in geography to assign a zone of influence or representativeness to the area around a given point—in this case, a monitoring site. The polygon defines the area closest to each site. Calculating Thiessen polygons is one of the simplest quantitative methods for estimating an area of representation around sites; however, the Thiessen polygons alone do not take into account study domain extents, geographic features, or meteorology. Thus, the next step in the area-served analysis was to consider the extent of the SJV study domain and the geography and terrain within each of the Thiessen polygon boundaries.

First, the initial area-served boundaries were clipped using the SJV study domain extents. Clipping the area-served boundaries within the study domain to the study domain extent eliminates the influence of area-served polygons for sites that lie outside of (in some cases, far outside of) the study domain. Next, high resolution Digital Elevation Model (DEM) data were used to better capture the influence of topography on each of the Thiessen polygon boundaries.

To improve the physical representation of the area-served boundaries, the boundaries were adjusted to a maximum elevation of 6,000 feet, thus accounting for topographic barriers. Because surface air parcels are not likely to travel across large mountain ranges, monitoring sites are not likely to represent the entire region defined by the Thiessen polygons; therefore, the areas of representativeness were restricted when geographic barriers were considered. Sites that are located outside of the boundary are used to constrain the area-served polygons within the SJVUAPCD boundary. The sites that lie outside of the SJVUAPCD boundary, and particularly those sites far beyond the boundary, do not effectively impact the area-served analysis within the SJVUAPCD boundary. **Figure 2-2** depicts the process for performing an area-served analysis.



Thiessen polygons developed for each monitoring network | Identify elevations above 6,000 feet | New polygons without areas where elevation is above 6,000 ft | Area Served analysis (area values of each site polygon)

Figure 2-2. The four-step process to perform an area-served analysis.

<u>Population-served Analysis</u>

After the area-served boundaries were developed for each site and pollutant, the population-served analysis was performed. The purpose of the population-served analysis was to determine the population coverage represented by each monitoring site and to identify the sites surrounded by the highest population densities. Those sites representing the greatest population are ranked highest in this analysis.

It is of interest to examine those areas within the SJV that have undergone substantial growth over the past several years and to examine monitoring site locations relative to areas of population growth. In many regions, areas that were once unpopulated are now fairly densely populated and, as a result, human encroachment and associated increases in emissions activity may impact monitoring sites. These impacts can change site characteristics (e.g., a former rural site may now be an urban site). In this analysis, the growth and spatial distribution of population throughout the study domain is examined.

To perform the population-served analysis, spatially resolved population data at the block-group level were acquired from the U.S. Census Bureau for 2000 and 2007 (ESRI, 2008) for the SJV. Block-group polygon centroids (the center-point of a polygon) were mapped within a GIS and population density values were calculated. The population density values were imposed on the area-served polygons from the previous analysis, and the population density within each polygon was calculated for 2000. The same procedure was performed for 2007, and the change in population density was calculated. The results of this analysis were used to identify areas of high population where there may be no monitoring sites and/or areas where population growth may have resulted in urban or suburban encroachment on a monitoring site. **Figure 2-3** depicts the process for performing the population-served analyses.

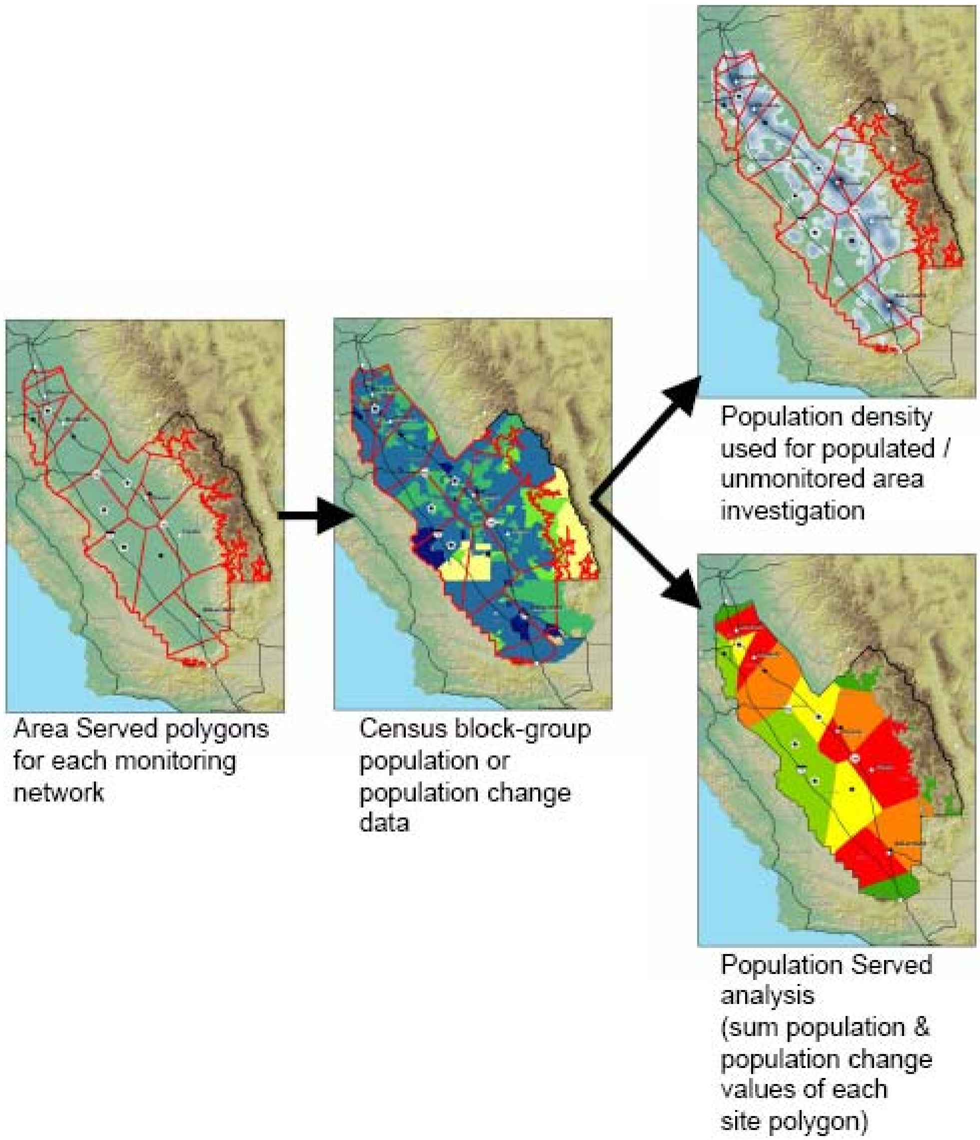


Figure 2-3. Illustration of the process for performing the population-served analysis.

Emissions-served Analysis

Taking the area- and population-served analyses one step further, an emissions-served analysis was performed. The emissions-served analysis examines the proximity of monitoring sites to emissions sources and emissions densities within each area-served boundary. This analysis was performed by overlaying spatially resolved emissions (or activity) data onto the area-served boundaries to investigate the potential emissions impacts on each monitoring site. The most recent gridded emissions data were collected from the CARB, and included TOG, NO_x, and PM emissions representative of a summer weekday in 2000. **Figure 2-4** depicts the process for performing the emissions-served analysis.

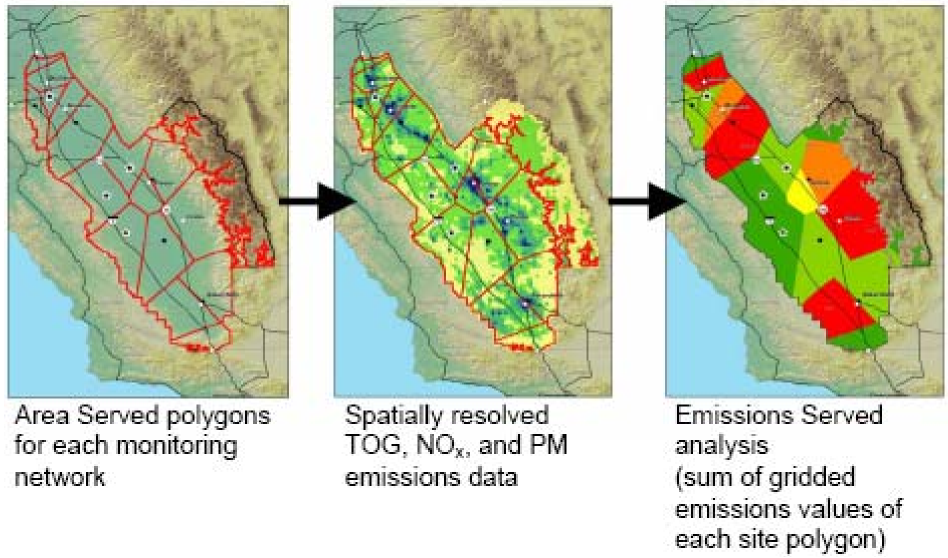


Figure 2-4. Illustration of the process for performing an emissions-served analysis.

Summary and Discussion of Results

The following sections discuss the findings of the area-, population-, and emissions-served analyses for ozone, $PM_{2.5}$, PM_{10}, NO_2, and CO. Because an individual monitoring site may measure a number of pollutants, the analyses are performed by first identifying the pollutant-specific networks and then performing the analyses for each individual network. The results below are presented for each of the pollutant networks in the SJV.

For each of the area-, population-, and emissions-served analyses, monitoring sites are ranked from highest to lowest. For the area-served analyses, the sites that represent the greatest area are ranked highest; for the population-served analyses, the sites that represent the greatest population are ranked highest; and for the emissions-served analyses, the sites that represent the most emissions are ranked highest. It is important to note that no one analysis stands alone and that the results are first viewed individually and then holistically in the context of the overall network.

Ozone Network

Table 2-11 depicts the area-, population-, population change, and emissions-served rankings for the ozone sites in the SJV. The sites are ordered such that moving from top to bottom down the left-hand column of the table corresponds to moving from the north to the south in the SJV. The results of this analysis indicate that the Turlock and Merced monitoring sites rank high in all categories, mainly due to the lack of monitors west of these sites (i.e., larger areas of representation result in larger population centers, and more emissions represented). Clovis and Parlier are also valuable sites based on this analysis.

Table 2-11. Summary of the area-, population-, population change, and emissions-served analyses for the ozone monitoring network. Red dots represent the high-ranking sites, green dots represent the mid-ranking sites, and blue dots represent the low-ranking sites.

Site Name (showing all sites within the SJV)	**Area Served**	**Population Served**	**Population Change**	**NO_x Emissions Served**	**TOG Emissions Served**
Stockton-Hazelton Street	green	red	red	red	red
Tracy-Airport	green	green	red	green	green
Modesto-14th Street	green	red	red	red	red
Turlock-S Minaret Street	red	red	red	red	red
Merced-S Coffee Avenue	red	red	red	red	red
Madera-Pump Yard	green	green	green	green	green
Fresno-Sierra Skypark #2	green	green	red	green	green
Clovis-N Villa Avenue	red	red	red	green	red
Fresno-1st Street	blue	red	green	green	red
Fresno-Drummond Street	green	red	green	green	red
Tranquility	red	green	green	red	green
Parlier	red	red	red	green	red
Sequoia/Kings Canyon NP	green	green	green	blue	green
Sequoia NP-Lower Kaweah	green	blue	blue	blue	green
Visalia-N Church Street	green	red	red	green	red
Hanford-S Irwin Street	green	green	green	green	green
Santa Rosa Rancheria	red	green	green	red	green
Porterville	red	green	green	green	red
Shafter-Walker Street	red	green	green	red	green
Oildale-3311 Manor Street	green	green	green	red	green
Bakersfield-GSH	blue	green	green	red	green
Bakersfield-5558 California Ave	green	red	red	red	green
Edison	green	green	green	green	green
Arvin-Bear Mountain Blvd	green	green	green	green	green
Maricopa-Stanislaus St	red	green	green	green	green
Lebec-Peace Valley Road	green	green	green	green	blue

- (red) Highest ranking sites (e.g., largest area-/population-/etc.-served value): Top 25% of all sites within the analysis
- (green) Middle ranking sites: 25%-75% of all sites within the analysis
- (blue) Lowest ranking sites (e.g., smallest NO_x emissions value): Bottom 25% of all sites within the analysis

Total ozone monitoring sites used in the analysis = 38

As indicated in the 2008 SJVUAPCD Network Plan, ozone monitoring in the SJV is directed toward measuring representative population exposures and maximum concentrations. As a result of these monitoring objectives, most ozone monitors operated by the SJVUAPCD are sited for either neighborhood- or urban-scale measurements as defined in the 2008 SJVUAPCD Network Plan (San Joaquin Valley Air Pollution Control District, 2008). The bar graph in **Figure 2-5** shows both the area-served and the population-served results for the ozone network in the SJV.

The dashed “Urban Scale” and “Neighborhood Scale” lines shown on the bar graphs in Figure 2-5 were estimated using the spatial scale guidelines in the SJVUAPCD Network Plan. Urban sites have an approximate radius of 4 to 50 km; neighborhood sites have an approximate radius of 0.5 to 4.0 km. The dashed lines on the graph indicate the approximate area around a site based on these radius designations. This information was used to help determine if sites are meeting their objectives and as a screening tool to identify sites that may warrant further investigation. The sites flagged with black stars above the bars in the figure indicate sites that were investigated in more detail.

Tracy, Turlock, and Clovis (marked with black stars in Figure 2-5) are designated as neighborhood-scale sites; however, based on the area-served analysis alone, they appear to be urban-scale sites. However, few of the sites are close enough to one another to be identified as neighborhood-scale sites using this approach.

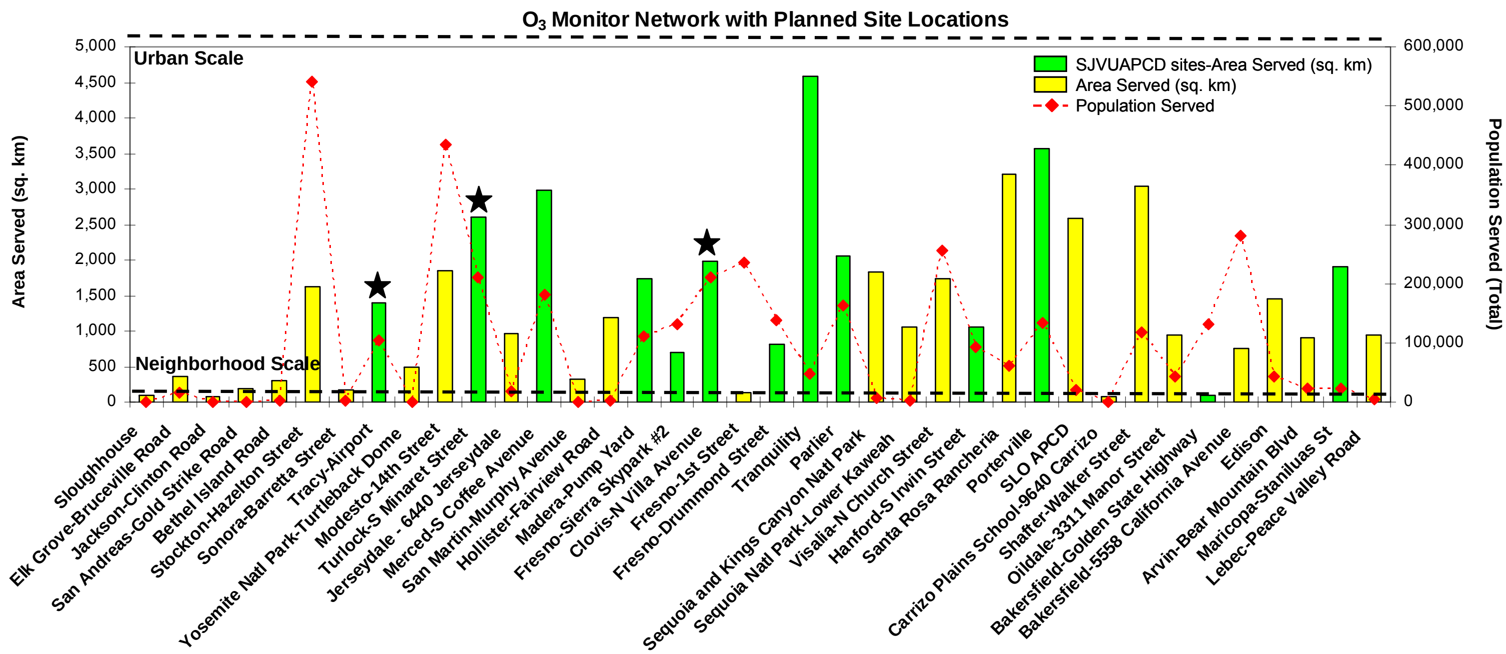


Figure 2-5. Summary of the area-served (in km^2 on the left axis) and population-served (people/km^2 on the right axis) analyses for ozone sites in the SJV. The SJVUAPCD-operated sites are shown as green bars and the sites operated by other agencies are indicated by yellow bars. The sites indicated with black stars above the bars are sites that were investigated in more detail.

Figure 2-6 shows a map of the area-served boundaries, the population density within each boundary, and the monitoring site locations. As shown in Figure 2-6, the Clovis site is situated in a fairly densely populated region of Clovis. A populated area northeast of Clovis in the foothill region appears to be unmonitored. The Tracy and Turlock sites appear to be situated to measure urban concentrations in densely populated areas, matching the objective of the sites.

There appears to be an area west of Merced (Los Banos area) that is populated and unmonitored (see the blue circle on the map). It should be noted that the planned ozone monitoring sites (Tranquility and Porterville) were included in this analysis. Both sites will represent a large area within the SJV; the Porterville site will be located in a fairly populated area and could therefore meet population exposure monitoring objectives. Also, the Tranquility site shrinks a potential gap in monitoring within the western side of the SJV. Tranquility and Porterville are appropriately sited to fill existing gaps in the network.

The findings of the population-change analysis were similar to those of the area- and population-served analyses. The areas northeast of Clovis and southwest of Turlock have high population growth and currently lack monitoring sites. Increases in population result in increased emissions activity. As shown in **Figure 2-7**, other areas with substantial population increases are Bakersfield, Visalia, and Merced, but the existing monitoring network coverage appears to be adequate in these areas.

The SJVUAPCD is planning to install two new sites in Porterville and Tranquility. The Porterville site will be placed in a fairly populated region, while the Tranquility site will be placed in an area with relatively low population. The map in Figure 2-7 indicates substantial growth in population south of the Tranquility site. This is mainly due to the construction of a new prison in that census block.

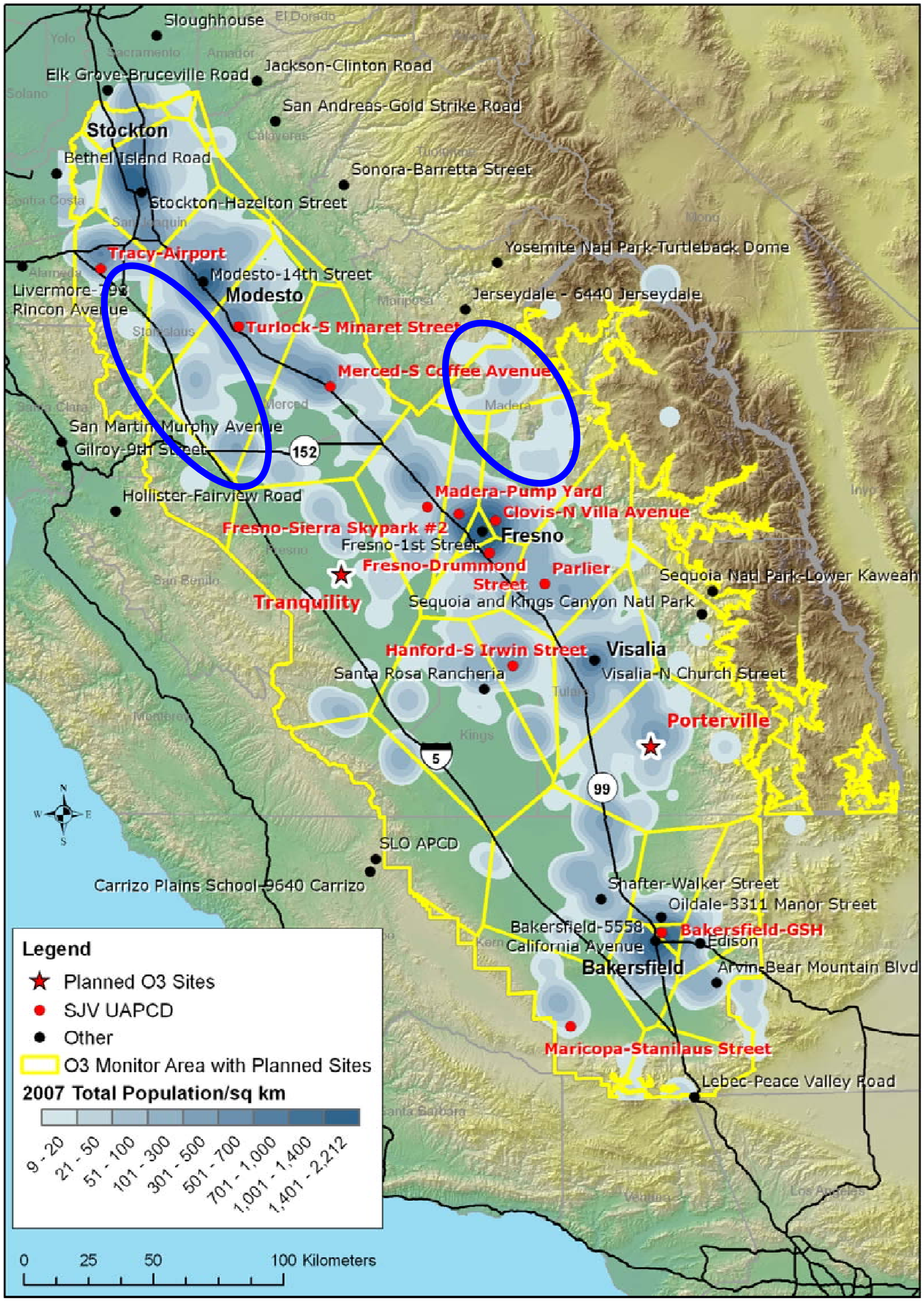


Figure 2-6. Map of the ozone monitoring sites, the area-served boundaries, and the population density in the SJV. Blue circles indicate areas that lack monitors and have substantial population.

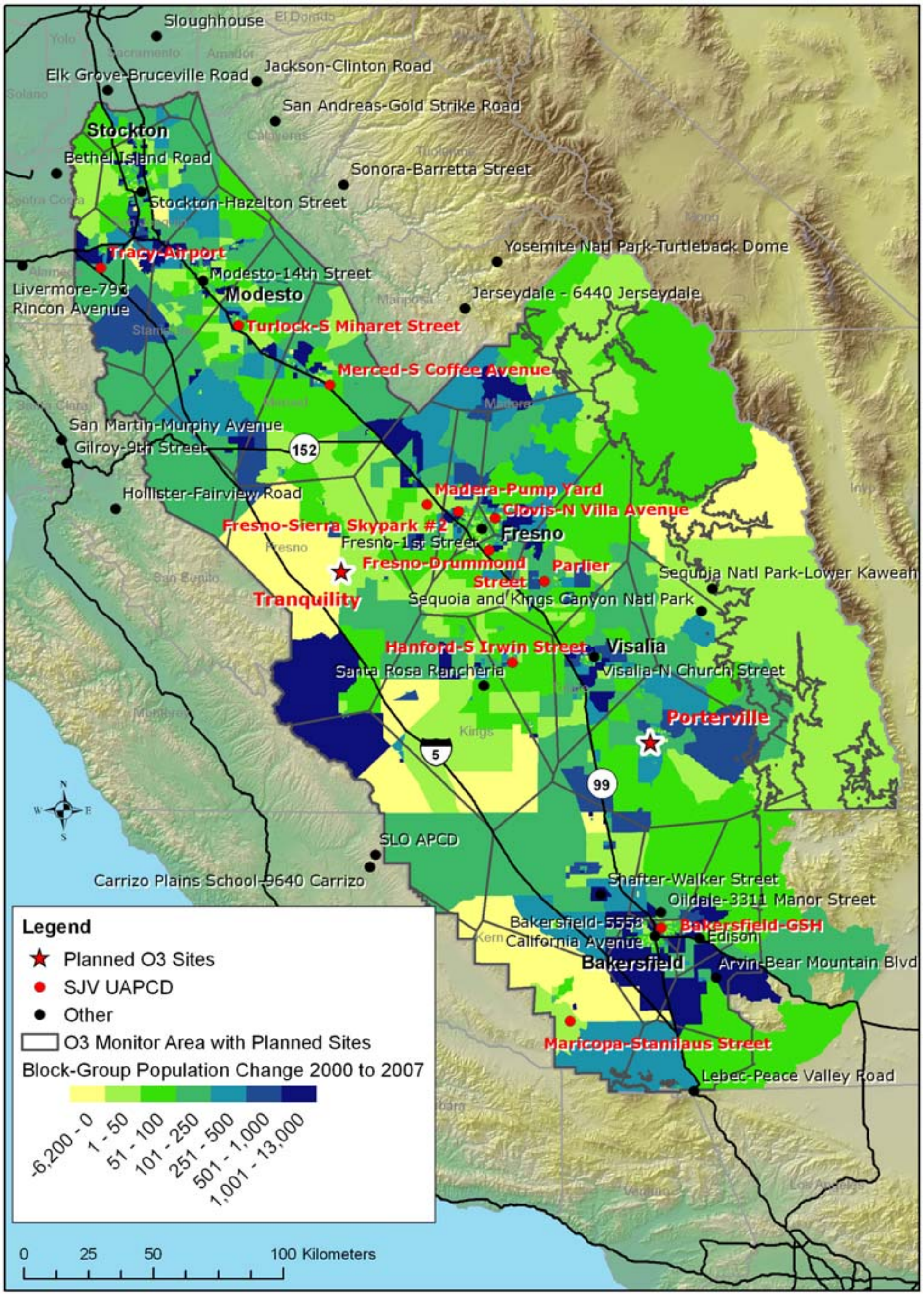


Figure 2-7. Map of the change in population from 2000 to 2007 for census block groups in the SJV overlaid with the area-served boundaries for the ozone monitoring network (ESRI, 2008).

Figure 2-8 depicts the area-served boundaries for the ozone monitor network overlaid on the TOG and NO_x spatially resolved (2-km) emissions inventory. The areas northeast of Clovis and west of Merced (Los Banos area) both have substantial TOG and NO_x emissions. Combined with the results of the area- and population-served analyses, this fact indicates that these areas may warrant monitoring sites.

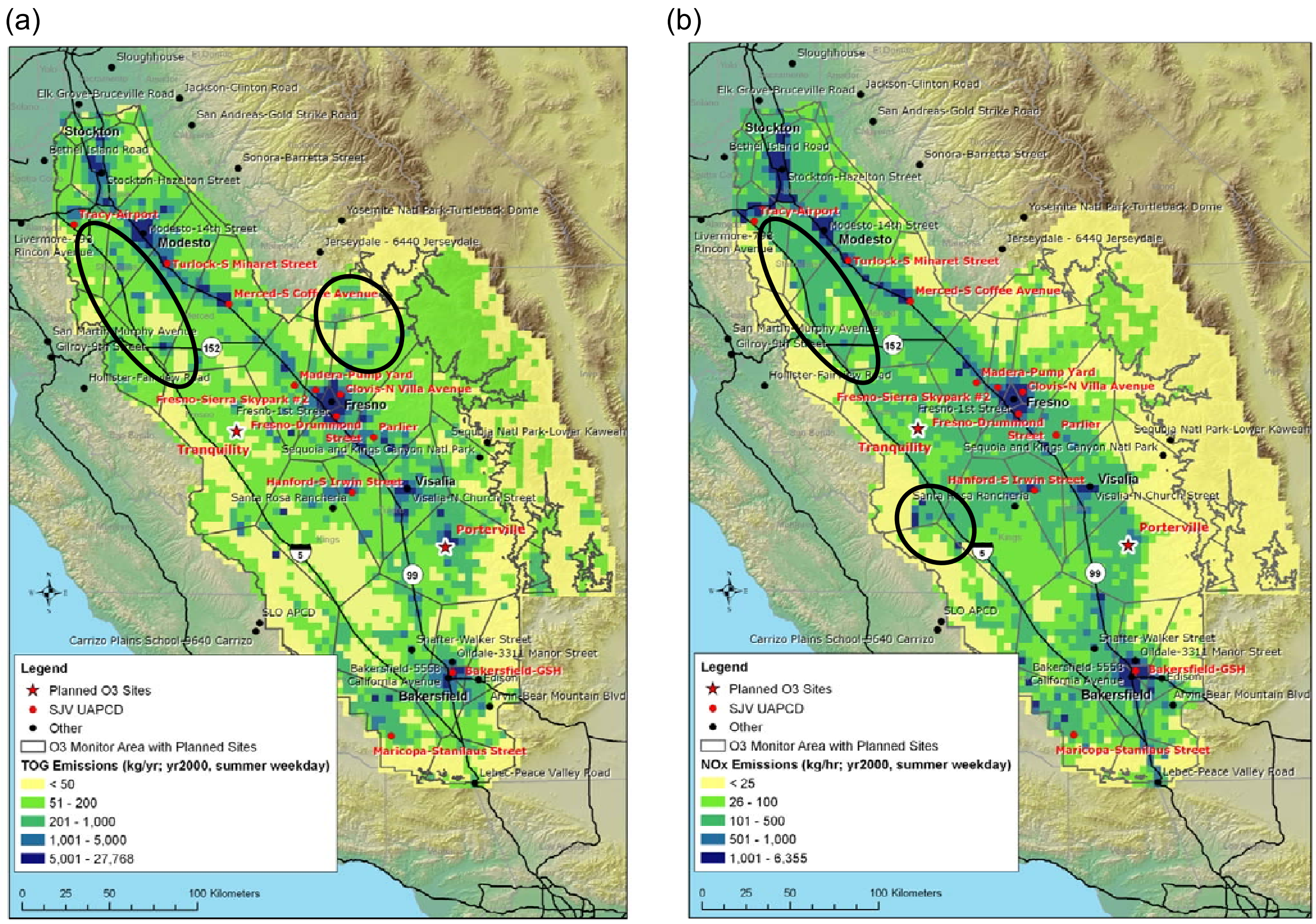


Figure 2-8. Area-served boundaries for the ozone monitor network overlaid on the spatially resolved (a) TOG and (b) NO_x emissions inventory. Black circles indicate areas of high emissions density that are unmonitored.

PM$_{2.5}$ 1-hr network

Table 2-12 shows the area-, population-, population change, and emissions-served results for the SJVUAPCD-operated $PM_{2.5}$ 1-hr continuous monitoring sites. The results of this analysis indicate that Turlock, Huron, and Corcoran cover the most area and that Turlock also ranks high for population-served, population change, and emissions-served. Note that Manteca is a planned site.

Table 2-12. Summary of area-, population-, population change, and emissions-served analyses for the $PM_{2.5}$ 1-hr continuous monitoring network. Red dots represent the high-ranking sites, green dots represent the mid-ranking sites, and blue dots represent the low-ranking sites.

Site Name (showing all sites within the SJV)	**Area Served**	**Population Served**	**Population Change**	**PM Emissions Served**
Stockton-Hazelton Street	● (green)	● (red)	● (red)	● (green)
Manteca	● (blue)	● (green)	● (green)	● (blue)
Tracy-Airport	● (green)	● (green)	● (green)	● (green)
Modesto-14th Street	● (green)	● (red)	● (red)	● (green)
Turlock-S Minaret Street	● (red)	● (green)	● (red)	● (red)
Madera	● (green)	● (green)	● (green)	● (green)
Clovis-N Villa Avenue	● (green)	● (green)	● (green)	● (red)
Fresno-1st Street	● (blue)	● (red)	● (green)	● (red)
Tranquility	● (green)	● (blue)	● (blue)	● (green)
Visalia-N Church Street	● (red)	● (red)	● (red)	● (red)
Huron	● (red)	● (green)	● (green)	● (green)
Corcoran-Patterson Avenue	● (red)	● (green)	● (green)	● (green)
Bakersfield-GSH	● (red)	● (green)	● (green)	● (red)
Bakersfield-5558 California Ave	● (green)	● (red)	● (red)	● (green)
Lebec-Peace Valley Road	● (green)	● (blue)	● (blue)	● (blue)

- (red) Highest ranking sites (e.g., largest area-/population-/etc.-served value): Top 25% of all sites within the analysis
- (green) Middle ranking sites: 25%-75% of all sites within the analysis
- (blue) Lowest ranking sites (e.g., smallest PM emissions value): Bottom 25% of all sites within the analysis

Total $PM_{2.5}$ 1-hr monitoring sites used in the analysis = 18

$PM_{2.5}$ monitoring in the SJV is aimed at measuring representative pollutant concentrations. Because of these monitoring objectives, most $PM_{2.5}$ 1-hr monitors in the SJV are sited to monitor either neighborhood- or urban-scale concentrations. **Figure 2-9** shows the area- and population-served results for the continuous $PM_{2.5}$ network in the SJV. The results indicate that Clovis, Huron, Corcoran, and Bakersfield–GSH are designed as neighborhood-scale sites; however, based on the area-served analysis alone, these sites appear to be urban-scale sites. Further investigation of the area-served boundaries for Huron, Corcoran, and Bakersfield–GSH (**Figure 2-10**) showed little or no population beyond the immediate monitoring locations; therefore, these sites appear to be correctly sited given the monitoring objectives for these sites.

Figure 2-10 highlights areas that are populated and unmonitored for continuous $PM_{2.5}$. The areas northeast of Clovis and west of Merced (Los Banos area) appear to be candidate locations for new monitoring sites, as was found by the ozone monitoring network analyses. In addition, the area between Corcoran and Bakersfield may warrant an additional $PM_{2.5}$ monitoring site. The SJVUAPCD is currently planning to install four additional $PM_{2.5}$ 1-hr monitors in Manteca, Madera, Tranquility, and Huron. These planned sites were included in this analysis. The sites planned for Manteca and Madera appear to be in populated areas and should fulfill population exposure monitoring objectives, while the Huron and Tranquility sites will fulfill apparent existing monitoring gaps in the western side of the SJV.

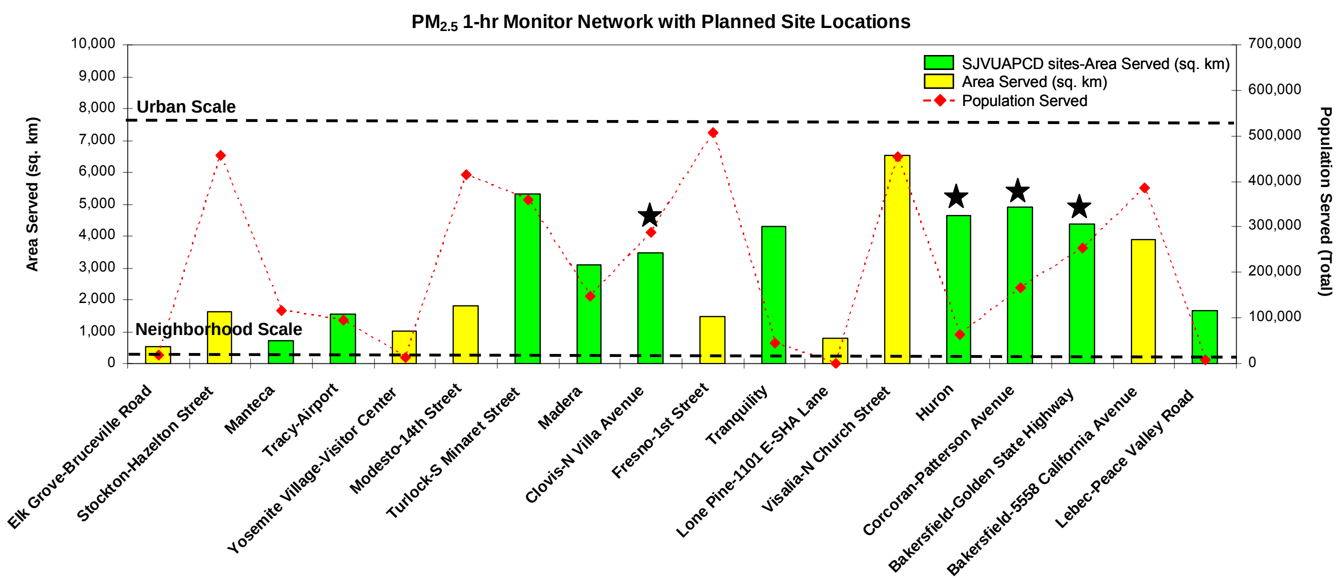


Figure 2-9. Summary of area-served (in km^2 on the left axis) and population-served (people/km^2 on the right axis) analyses for the $PM_{2.5}$ 1-hr continuous sites in the SJV. The sites indicated with black stars above the bars are sites that were investigated in more detail.

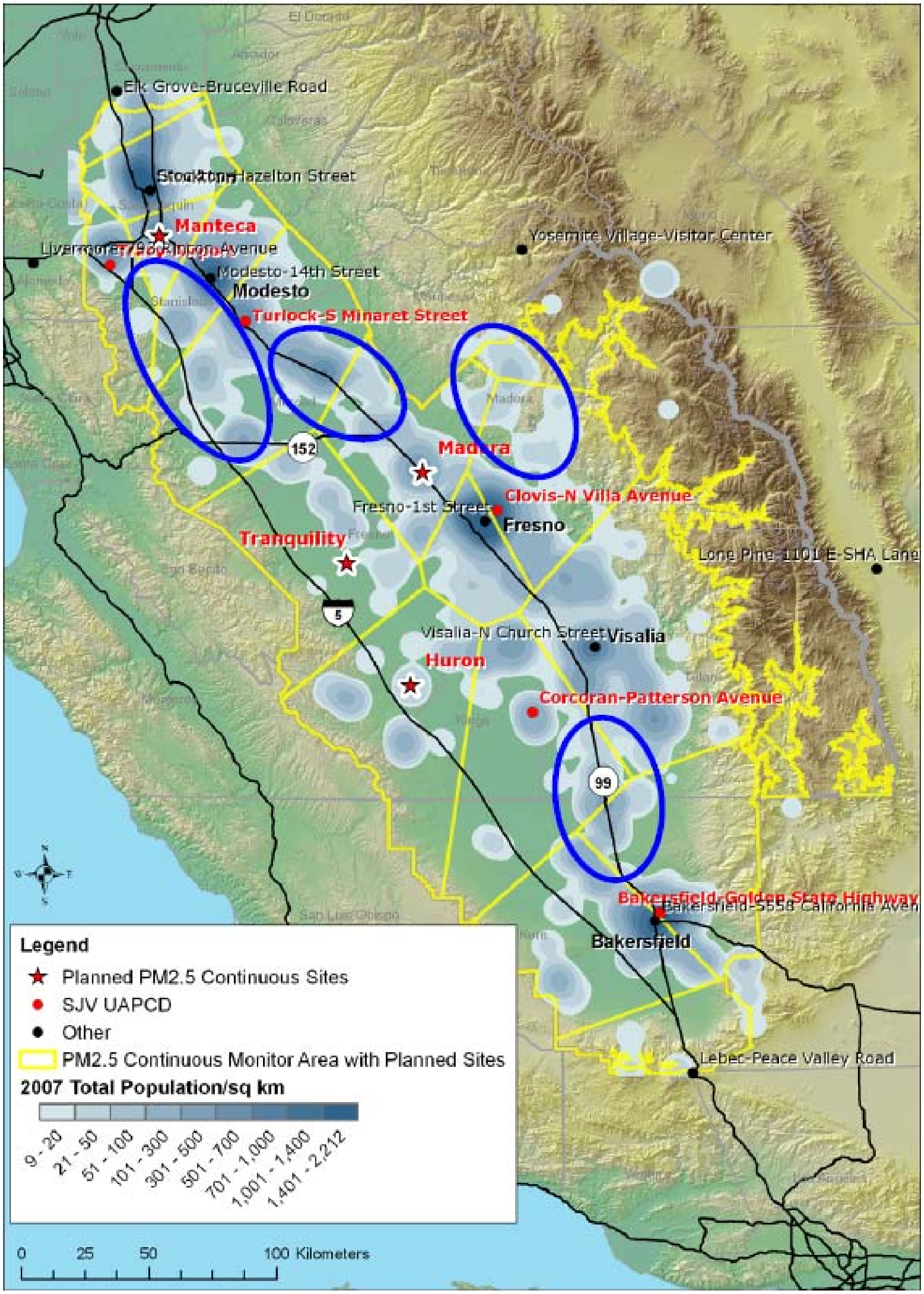


Figure 2-10. Map of the $PM_{2.5}$ 1-hr continuous monitoring sites, the area-served boundaries, and the population density in the SJV. Areas that have substantial population but are unmonitored are highlighted with blue circles.

The results of the population change analysis relative to the $PM_{2.5}$ 1-hr continuous monitoring network are shown in **Figure 2-11** and again indicate similar findings to the ozone network assessment. The areas northeast of Clovis, west of Merced (Los Banos area), and southeast of Corcoran all have high population growth, but there are currently no monitoring sites in these areas. The sites planned for Madera and Manteca will be placed in regions where population has grown; sites at Tranquility and Huron will be in areas with low population but will fill monitoring gaps in the western region of the valley. Again, note that the area just south of Tranquility is shown as an area of high population growth, mainly due to the construction of a new prison in the area.

Figure 2-12 shows the area-served boundaries for the $PM_{2.5}$ 1-hr monitor network overlaid on the 2-km PM emissions inventory. The results of the emissions-served analysis suggest potential benefits of adding continuous PM sites in the northwestern and central regions of the SJV (indicated with circles in Figure 2-12).

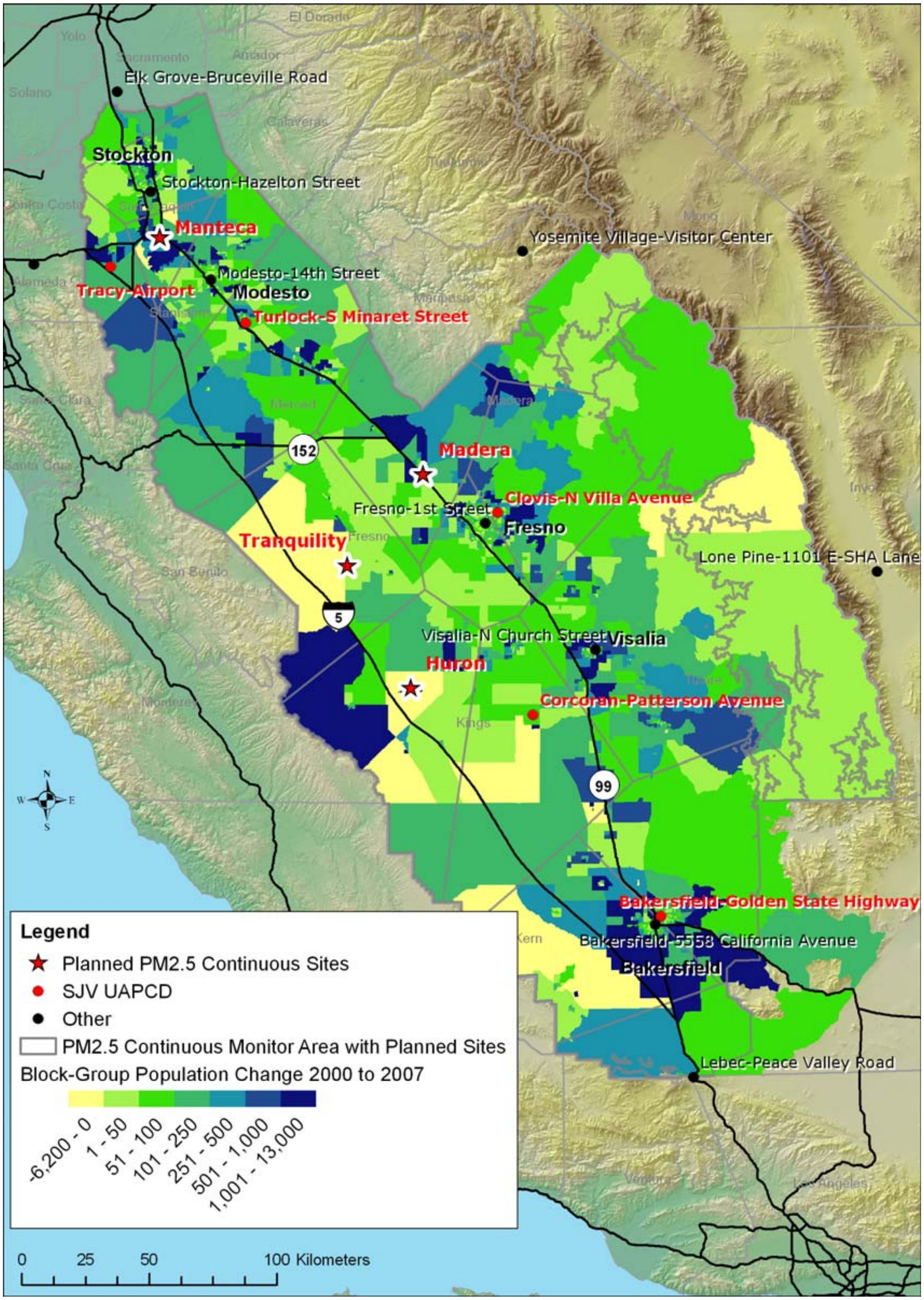


Figure 2-11. Map of the change in population from 2000 to 2007 for census block groups in the SJV overlaid with the area-served boundaries for the $PM_{2.5}$ network (ESRI, 2008).

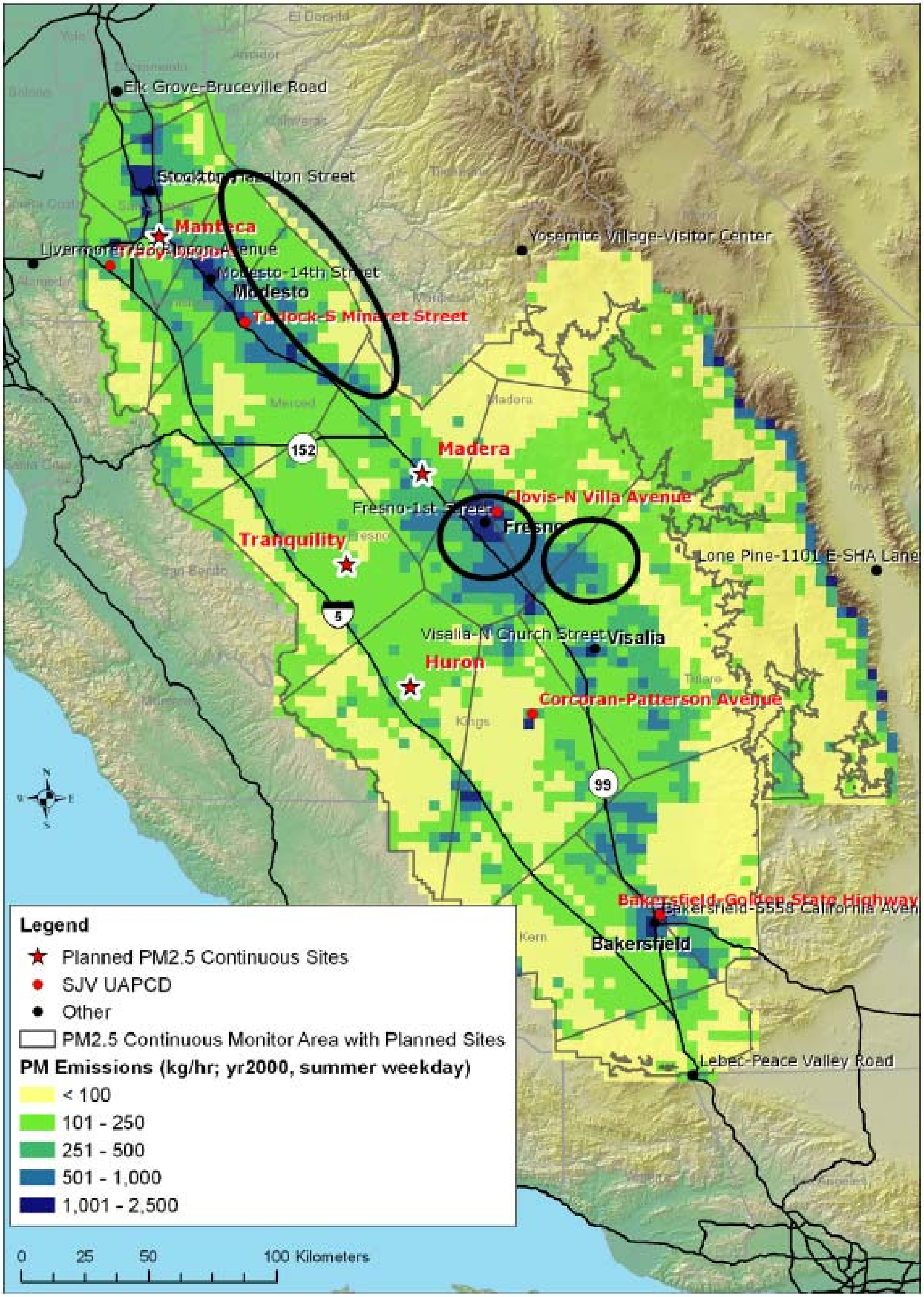


Figure 2-12. Area-served boundaries for the $PM_{2.5}$ 1-hr monitor network overlaid with the spatially resolved (2-km) gridded PM emissions inventory. Black circles indicate areas that are unmonitored and where PM emissions density is high.

$PM_{2.5}$ 24-hr network

Table 2-13 shows the area-served, population-served, population change, and emissions-served analysis results for the SJVUAPCD-operated $PM_{2.5}$ 24-hr monitoring sites. The results of the analysis indicate that Merced, Clovis, and Corcoran rank highest with the most area and emissions served.

Table 2-13. Summary of the area-, population-, population change, and emissions-served analyses for the $PM_{2.5}$ 24-hr monitoring network. Red dots represent the high-ranking sites, green dots represent the mid-ranking sites, and blue dots represent the low-ranking sites.

Site Name (showing all sites within the SJV)	**Area Served**	**Population Served**	**Population Change**	**PM Emissions Served**
Stockton-Hazelton Street	🟢	🔴	🔴	🟢
Modesto-14th Street	🟢	🔴	🔴	🔴
Merced-2334 M Street	🔴	🟢	🟢	🔴
Clovis-N Villa Avenue	🔴	🟢	🟢	🟢
Fresno-1st Street	🟢	🔴	🟢	🟢
Fresno-Hamilton and Winery	🟢	🟢	🟢	🟢
Visalia-N Church Street	🔴	🔴	🔴	🔴
Corcoran-Patterson Avenue	🔴	🟢	🟢	🔴
Bakersfield-GSH	🟢	🟢	🟢	🟢
Bakersfield-5558 California Ave	🟢	🟢	🔴	🟢
Bakersfield-410 E Planz Road	🟢	🟢	🟢	🟢

🔴 Highest ranking sites (e.g., largest area-/population-/etc.-served value): Top 25% of all sites within the analysis
🟢 Middle ranking sites: 25%-75% of all sites within the analysis
🔵 Lowest ranking sites (e.g., smallest PM emissions value): Bottom 25% of all sites within the analysis
Total $PM_{2.5}$ 24-hr monitoring sites included in this analysis = 16

Figure 2-13 shows the area-served boundaries for the $PM_{2.5}$ 24-hr network overlaid with population density. The results for the $PM_{2.5}$ 24-hr network are similar to those for the ozone and $PM_{2.5}$ 1-hr network in that the western side of the SJV appears to lack monitors. However, the two $PM_{2.5}$ 1-hr monitors that are planned for Tranquility and Huron should fill the gap in $PM_{2.5}$ monitoring within the SJV. Again, the areas northeast of Clovis and east of Corcoran are also potential areas for placing new monitors relative to population.

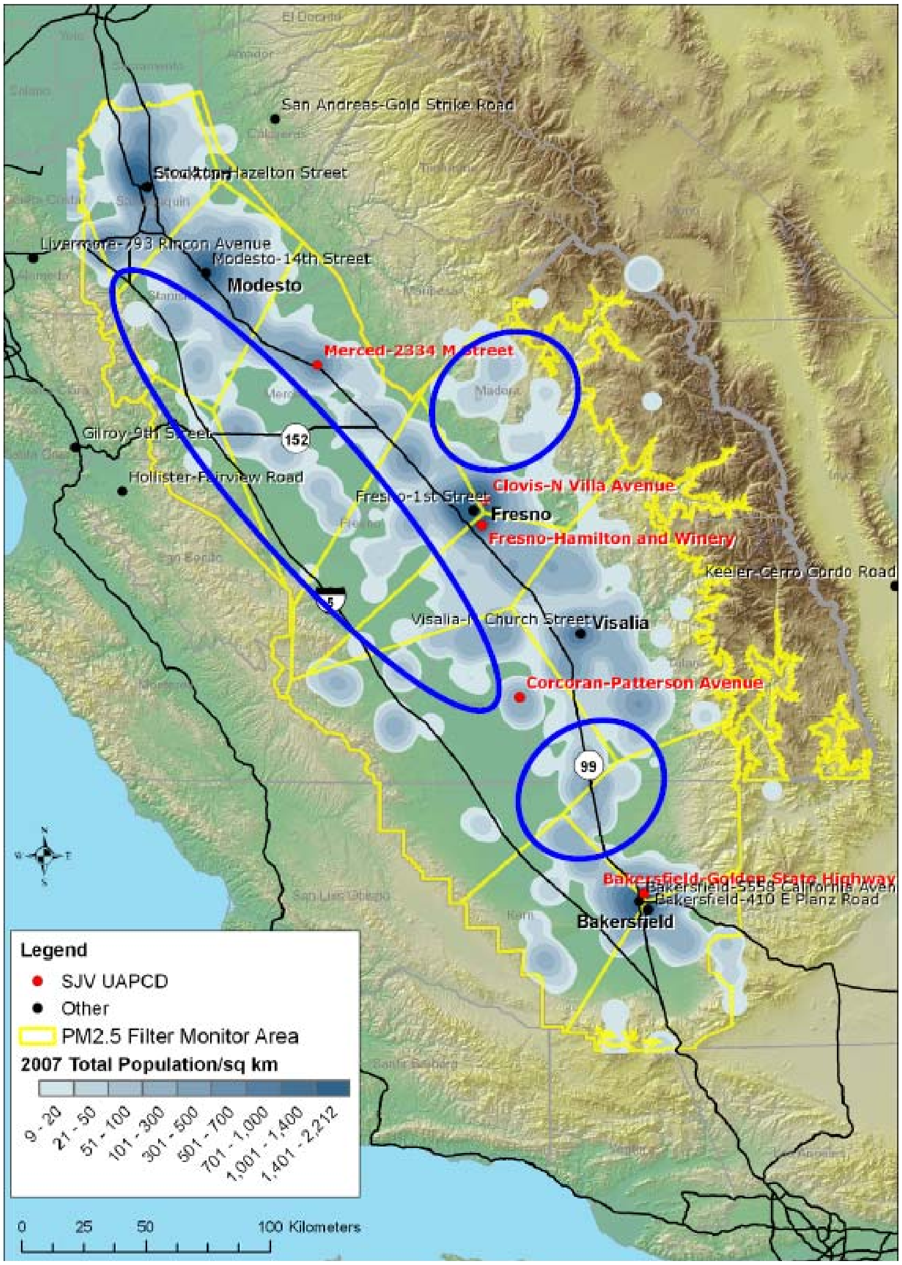


Figure 2-13. Area-served boundaries for the $PM_{2.5}$ 24-hr monitoring network overlaid with 2007 population density. Blue circles indicate areas that are unmonitored for 24-hr $PM_{2.5}$ but have substantial population.

Three monitors currently exist in Fresno, two of which measure both 1-hr and 24-hr $PM_{2.5}$ (Fresno First St. and Clovis). The third site, Fresno–Hamilton Winery, only measures 24-hr $PM_{2.5}$ but is an important monitoring site in southern Fresno. The SJVUAPCD might consider adding a continuous $PM_{2.5}$ site northeast of Clovis to help fill gaps in the continuous $PM_{2.5}$ network. Supplemental graphs and maps for all of the bottom-up analyses for the $PM_{2.5}$ 24-hr monitoring network can be found in Appendix B.

PM$_{10}$ 1-hr network

Table 2-14 shows the area-served, population-served, population change, and emissions-served results for the SJVUAPCD-operated PM$_{10}$ 1-hr monitoring sites. Unlike the previously discussed networks, the PM$_{10}$ 1-hr network is fairly sparse, with only five sites in the entire SJV (including the planned Madera site). The SJVUAPCD operates four of the five sites. Because the PM$_{10}$ 1-hr network is relatively sparse, the area-, population-, and emissions-served results indicate that the sites represent much larger areas than do sites for the more robust networks (i.e., ozone and PM$_{2.5}$). For example, because there are no sites in Stockton and Modesto, the area-served boundary for the Tracy site encompasses these areas, thus producing high values for population-served, population change, and emissions-served.

Table 2-14. Summary of the area-, population-, population change, and emissions-served analyses for the PM$_{10}$ 1-hr monitoring network. Red dots represent the high-ranking sites, green dots represent the mid-ranking sites, and blue dots represent the low-ranking sites.

Site Name (showing all sites within the SJV)	**Area Served**	**Population Served**	**Population Change**	**PM Emissions Served**
Tracy-Airport	● (green)	● (red)	● (red)	● (red)
Madera	● (red)	● (green)	● (green)	● (green)
Fresno-1st Street	● (green)	● (red)	● (red)	● (green)
Corcoran-Patterson Avenue	● (red)	● (green)	● (green)	● (red)
Bakersfield-GSH	● (green)	● (green)	● (green)	● (green)

• Highest ranking sites (e.g., largest area-/population-/etc.-served value): Top 25% of all sites within the analysis
• Middle ranking sites: 25%-75% of all sites within the analysis
• Lowest ranking sites (e.g., smallest PM emissions value): Bottom 25% of all sites within the analysis
Total PM$_{10}$ 1-hr monitoring sites included in this analysis = 8

Figure 2-14 shows the area-served boundaries for the PM$_{10}$ 1-hr network overlaid with the 2007 population density. Areas that have substantial population but no monitoring sites are indicated with blue circles. A planned Madera site will help fill gaps in the network along the north-south corridor of the SJV. However, there are no PM$_{10}$ 1-hr sites in the eastern and western portions of the SJV. Potential improvements to the PM$_{10}$ 1-hr monitoring network might include adding PM$_{10}$ monitors at the planned PM$_{2.5}$ 1-hr monitor sites (i.e., Huron, Manteca, and Tranquility) and/or adding 1-hr PM$_{10}$ monitors at existing 24-hr PM$_{10}$ sites. Twenty-four-hour data are generally more reliable than continuous data; however, continuous data can be used in conjunction with 24-hr data to help explain the phenomena and conditions that lead to high PM episodes. Currently, the PM$_{10}$ 24-hr network consists of 15 sites (8 of which are operated by the SJVUAPCD) in areas that would fill gaps in the current PM$_{10}$ 1-hr monitoring network. Supplemental graphs and maps for the PM$_{10}$ 1-hr monitoring network assessment can be found in Appendix B.

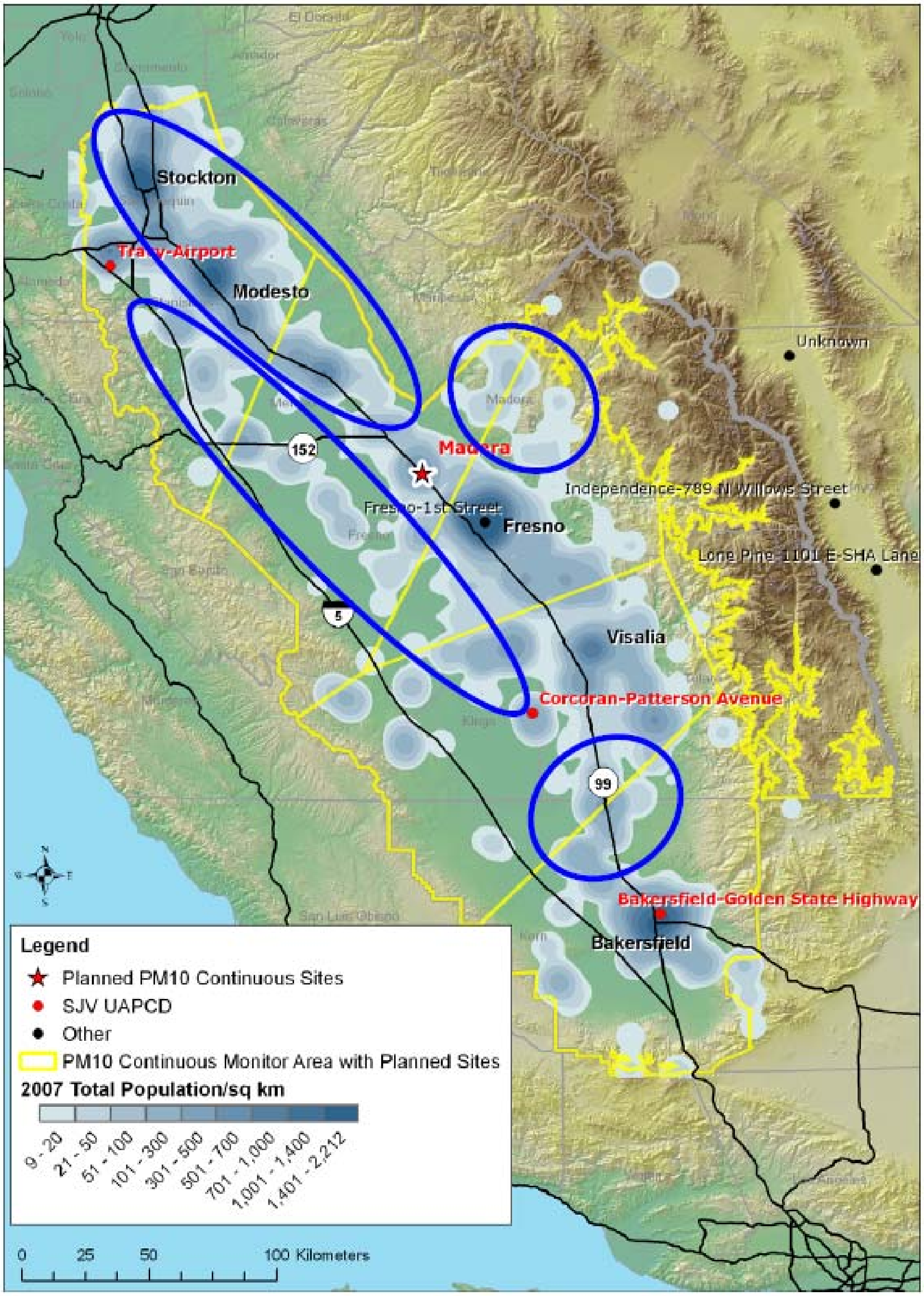


Figure 2-14. Area-served boundaries for the PM_{10} 1-hr monitoring network overlaid with 2007 population density. Blue circles indicate areas that are unmonitored for continuous PM_{10} but have substantial population.

PM_{10} 24-hr Network

Table 2-15 shows the area-, population-, population change, and emissions-served results for the SJVUAPCD-operated PM_{10} 24-hr monitoring sites. The results of this analysis indicate that the Stockton site is important for population coverage, while Turlock, Merced, and Fresno–Drummond are important sites for monitoring emissions.

Table 2-15. Summary of the area-, population-, population change, and emissions-served analyses for the PM_{10} 24-hr monitoring network. Red dots represent the high-ranking sites, green dots represent the mid-ranking sites, and blue dots represent the low-ranking sites.

Site Name (showing all sites within the SJV)	**Area Served**	**Population Served**	**Population Change**	**PM Emissions Served**
Stockton-Wagner-Holt School	● (green)	● (red)	● (red)	● (green)
Stockton-Hazelton Street	● (green)	● (red)	● (red)	● (green)
Modesto-14th Street	● (green)	● (red)	● (red)	● (red)
Turlock-S Minaret Street	● (green)	● (green)	● (green)	● (red)
Merced-2334 M Street	● (red)	● (green)	● (green)	● (red)
Clovis-N Villa Avenue	● (red)	● (red)	● (red)	● (green)
Fresno-1st Street	● (green)	● (red)	● (red)	● (red)
Fresno-Drummond Street	● (green)	● (green)	● (green)	● (red)
Visalia-N Church Street	● (red)	● (red)	● (red)	● (red)
Hanford-S Irwin Street	● (green)	● (green)	● (green)	● (green)
Santa Rosa Rancheria	● (red)	● (green)	● (green)	● (red)
Corcoran-Patterson Avenue	● (red)	● (green)	● (green)	● (green)
Oildale-3311 Manor Street	● (red)	● (green)	● (green)	● (green)
Bakersfield-GSH	● (green)	● (green)	● (green)	● (green)
Bakersfield-5558 California Ave	● (red)	● (red)	● (red)	● (green)

• (red) Highest ranking sites (e.g., largest area-/population-/etc.-served value): Top 25% of all sites within the analysis
• (green) Middle ranking sites: 25%-75% of all sites within the analysis
• (blue) Lowest ranking sites (e.g., smallest PM emissions value): Bottom 25% of all sites within the analysis
Total PM_{10} 24-hr monitoring sites included in this analysis = 25

Figure 2-15 shows the area-served boundaries for the PM_{10} 24-hr network overlaid with 2007 population density. Fifteen PM_{10} 24-hr monitors are currently located in the SJV, eight of which are operated by the SJVUAPCD. The results of the PM_{10} 24-hr network are consistent with the results for the other pollutant networks. Specifically, the areas northeast of Clovis, the western region of the SJV, and the region between Corcoran and Bakersfield may warrant additional PM_{10} monitors.

Supplemental graphs and maps for all bottom-up analyses of the PM_{10} 24-hr monitoring network can be found in Appendix B.

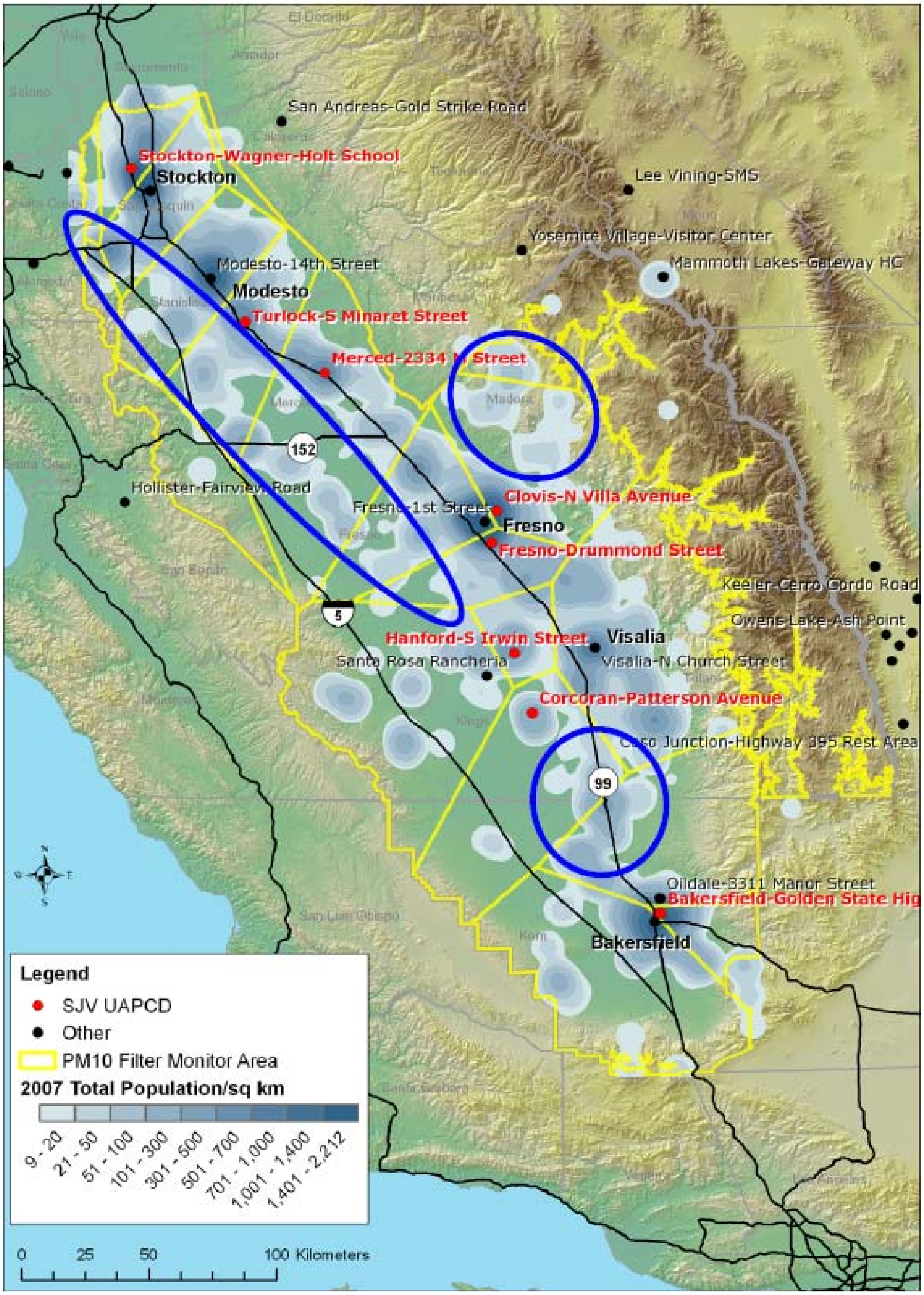


Figure 2-15. Area-served boundaries for the PM_{10} 24-hr monitoring network overlaid with 2007 population density in the SJV. Blue circles indicate areas that are unmonitored for 24-hr PM_{10} but have substantial population.

<u>NO_2 network</u>

Table 2-16 depicts the area-served, population-served, and population change results for the SJVUAPCD-operated NO_2 monitoring sites. The results of these analyses indicate that the Turlock site ranks highest among SJVUAPCD-operated sites. The Fresno sites, though representing small areas due to a cluster of monitors in the Fresno area, are important sites for population coverage and emissions.

Table 2-16. Summary of the area-served, population-served, and population change analyses for the NO_2 monitoring network. Red dots represent the high-ranking sites, green dots represent the mid-ranking sites, and blue dots represent the low-ranking sites.

Site Name **(showing all sites within the SJV)**	**Area Served**	**Population Served**	**Population Change**
Stockton-Hazelton Street	● (green)	● (red)	● (red)
Tracy-Airport	● (green)	● (green)	● (green)
Turlock-S Minaret Street	● (red)	● (red)	● (red)
Merced-S Coffee Avenue	● (green)	● (green)	● (green)
Madera-Pump Yard	● (red)	● (green)	● (green)
Clovis-N Villa Avenue	● (green)	● (green)	● (red)
Fresno-Sierra Skypark #2	● (blue)	● (green)	● (green)
Fresno-1st Street	● (blue)	● (red)	● (green)
Fresno-Drummond Street	● (blue)	● (green)	● (green)
Parlier	● (green)	● (green)	● (green)
Visalia-N Church Street	● (red)	● (red)	● (red)
Hanford-S Irwin Street	● (red)	● (green)	● (green)
Shafter-Walker Street	● (red)	● (green)	● (green)
Bakersfield-GSH	● (green)	● (green)	● (green)
Bakersfield-5558 California Ave	● (green)	● (red)	● (red)
Edison	● (green)	● (blue)	● (blue)
Arvin-Bear Mountain Blvd	● (green)	● (blue)	● (blue)

• (red) Highest ranking sites (e.g., largest area-/population-/etc.-served value): Top 25% of all sites within the analysis
• (green) Middle ranking sites: 25%-75% of all sites within the analysis
• (blue) Lowest ranking sites (e.g., smallest NO_x emissions value): Bottom 25% of all sites within the analysis
Total NO_2 monitoring sites included in this analysis = 20

Figure 2-16 shows the area-served boundaries for the NO_2 monitoring network overlaid with 2007 population density. Overall, the sites in the NO_2 network appear to meet their intended monitoring objectives. However, Figure 2-16 indicates a potential gap in the network along the western side of the SJV (see the blue circles on the map). Although the SJV does not exceed federal or state standards for NO_2, and it is likely that NO_2 levels will continue to decline as a result of NO_x controls, an NO_2 monitor at the planned Tranquility ozone site could help fill the gap along the western side of the SJV. Nevertheless, the western side of the SJV is too large to realistically capture data with only one NO_2 monitoring location. Supplemental graphs and maps for the bottom-up analyses of the NO_2 monitoring network can be found in Appendix B.

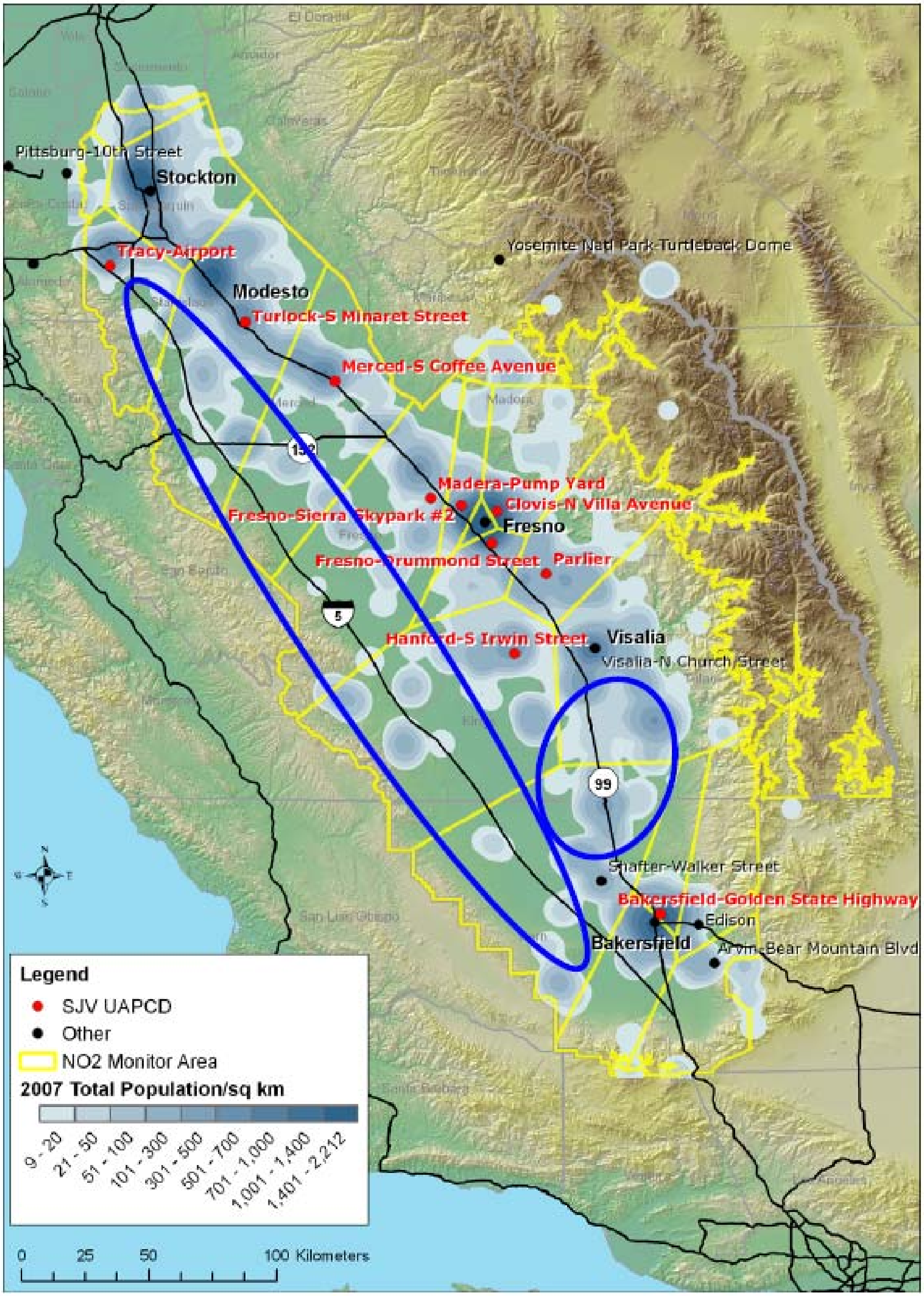


Figure 2-16. Area-served boundaries for the NO_2 monitoring network overlaid with 2007 population density in the SJV. Blue circles indicate areas that are unmonitored for NO_2 but have substantial population.

CO Network

Table 2-17 shows the results of the area-served, population-served, and population change analyses for the CO monitoring sites. The SJVUAPCD operates eight CO sites, three of which are located in and around Fresno. The Turlock, Fresno–Drummond, and Bakersfield–GSH sites rank highest based on the bottom-up analyses because they represent large areas and high population density.

Table 2-17. Summary of the area-served, population-served, and population change analyses for the CO monitoring network. Red dots represent the high-ranking sites, green dots represent the mid-ranking sites, and blue dots represent the low-ranking sites.

Site Name (showing all sites within the SJV)	**Area Served**	**Population Served**	**Population Change**
Stockton-Hazelton Street	● (green)	● (red)	● (red)
Modesto-14th Street	● (green)	● (green)	● (green)
Turlock-S Minaret Street	● (red)	● (green)	● (green)
Fresno-Sierra Skypark #2	● (green)	● (green)	● (green)
Clovis-N Villa Avenue	● (green)	● (green)	● (green)
Fresno-1st Street	● (blue)	● (green)	● (green)
Fresno-Drummond Street	● (red)	● (red)	● (red)
Bakersfield-GSH	● (red)	● (red)	● (red)

• (red) Highest ranking sites (e.g., largest area-/population-/etc.-served value): Top 25% of all sites within the analysis
• (green) Middle ranking sites: 25%-75% of all sites within the analysis
• (blue) Lowest ranking sites (e.g., smallest NO_x emissions value): Bottom 25% of all sites within the analysis
Total CO monitoring sites included in this analysis = 11

According to the site-by-site analyses and the SJV Network Plan, CO concentrations in the SJV are far below the NAAQS and the SJVUAPCD is not required to monitor for CO. However, the SJVUAPCD plans to add high-sensitivity CO instruments at the Clovis and Bakersfield–GSH sites. **Figure 2-17** shows the area-served boundaries for the CO network overlaid with the 2007 population density. Of the eight CO monitors in the SJV, four are located in the greater Fresno area (three of which are run by the SJVUAPCD), as shown in Figure 2-17. With the addition of a trace CO monitor at the Clovis site, the relocation of one or two of the other sites in Fresno could be beneficial, as there may be some redundancy in CO sites in the Fresno area. Figure 2-17 depicts areas of high population that may warrant a CO monitor (as shown by blue circles). Supplementary graphs and maps for the CO bottom-up analyses can be found in Appendix B.

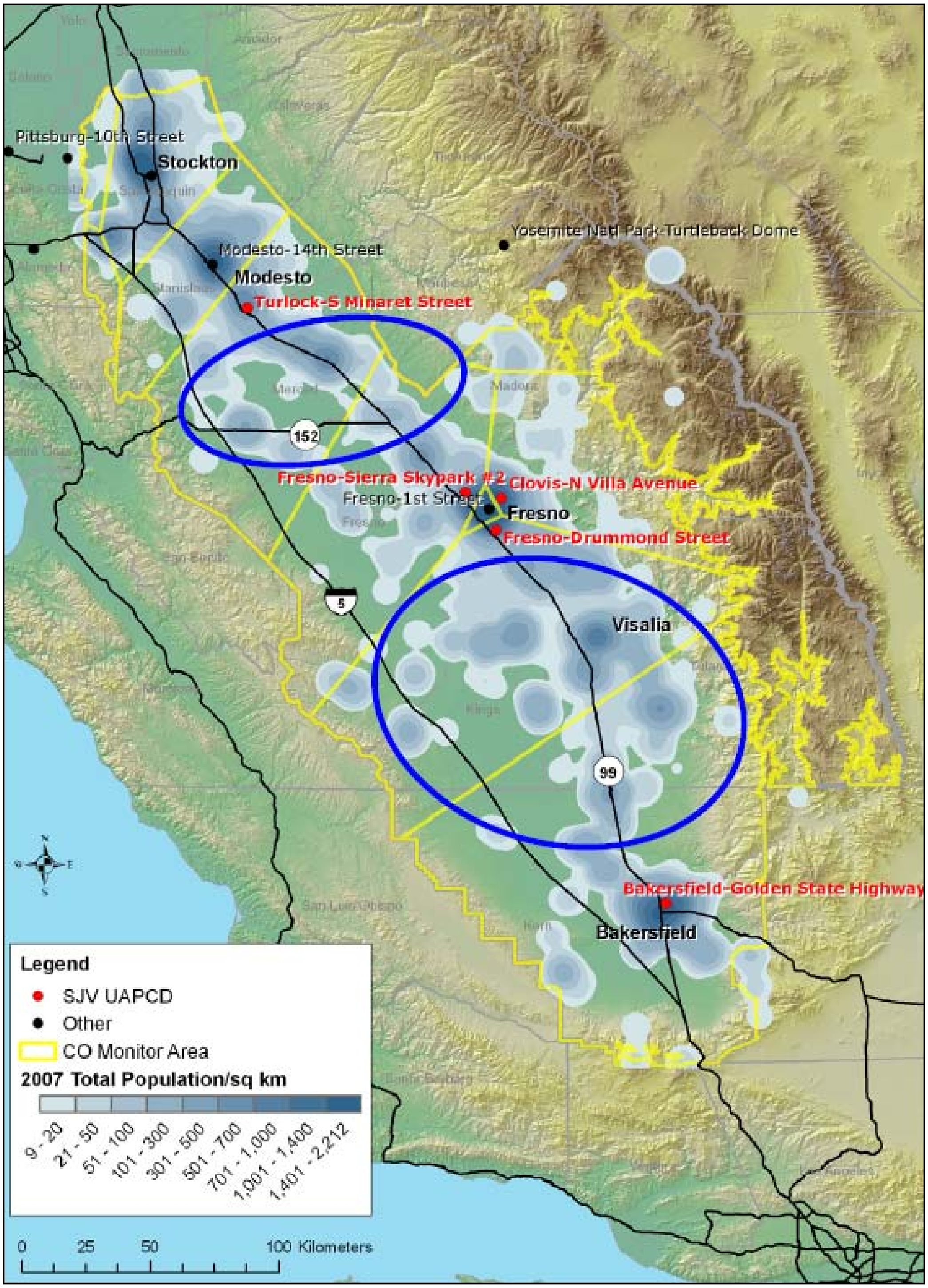


Figure 2-17. Area-served boundaries for the CO monitoring network overlaid with 2007 population density in the SJV. Blue circles indicate areas that are unmonitored for CO but have substantial population.

2.3 TECHNICAL APPROACH AND FINDINGS FOR THE PAMS NETWORK ASSESSMENT

The PAMS program collects ambient air measurements in areas classified as serious, severe, or extreme ozone nonattainment, as required by Section 182(c)(1) of the Clean Air Act. PAMS are used to collect data for a target list of VOCs, nitrogen oxides (NO_x, NO_y), ozone, and surface and upper-air meteorological measurements. In 2006, the EPA reduced minimum PAMS monitoring requirements to establish a network that meets the national objectives of the program while freeing up resources for states to tailor their networks to suit specific data needs. Overall, the changes significantly reduce the costs of the minimum PAMS monitoring requirements and allow states to re-invest these savings in region-specific PAMS monitoring activities.

In 2008, STI performed an assessment of the national PAMS network for the EPA. This assessment included performing the same site-by-site analyses described in Section 2.2 above as well as several other analyses to examine areas of high ozone concentrations relative to monitoring site types, locations, and objectives. The result of this work was a report that was delivered to EPA in September 2008 entitled *Network Assessment for the National Photochemical Assessment Monitoring Stations (PAMS) Program* (McCarthy et al., 2008).

The PAMS Network Assessment project was a collaboration of federal, regional, and state PAMS participants with the objectives of assessing how well the current PAMS network is meeting its monitoring objectives; determining which sites are most useful for meeting these objectives; identifying potentially redundant, ineffective, or unnecessary sites; and assessing other enhanced ozone monitoring activities that may prove useful. This section contains the key findings and results of the national PAMS network assessment for Region 9 and of the SJV PAMS network assessment. For a detailed discussion of the national PAMS network assessment and analysis methods, refer to the EPA draft report (McCarthy et al., 2008).

2.3.1 Overview of the PAMS Network

The PAMS network was established in the mid-1990s in ozone nonattainment areas to provide information on the effectiveness of control strategies, emissions tracking, trends, and exposure. State and local air pollution control agencies are responsible for operation of the PAMS sites. A PAMS site typically monitors 56 target hydrocarbons and 2 carbonyl compounds, ozone, NO_x and/or NO_y, and meteorological measurements. The conceptual PAMS network design was developed to include measurements collected at defined locations within an urban region to meet specific objectives based on a site's location relative to emissions and transport pathways in a given area. The site types and objectives are defined as follows:

- Type 1 – Upwind and background characterization site
- Type 2 – Maximum ozone precursor emissions impact sites
- Type 3 – Maximum ozone concentration sites
- Type 4 – Extreme downwind monitoring sites

EPA Region 9 consists of California, Nevada, Arizona, and Hawaii. PAMS areas include the South Coast (Los Angeles/Riverside), SJV, Sacramento, Phoenix, and San Diego. Region 9 has the most severe ozone areas and has the highest and most frequent number of ozone exceedances in the nation. Region 9 has approximately 21 active monitoring sites, six of which are operated by the SJVUAPCD. The SJVUAPCD sites are located in Madera, Clovis, Parlier, Shafter, Bakersfield–GSH, and Arvin.

Several analyses were performed as part of the national PAMS network assessment to address the objectives of the PAMS sites, including the number of parameters monitored, data completeness, percent above MDL, trend length, measured concentrations, attainment status, network density, and maximum ozone locations. As part of the SJV study, several additional analyses were performed, including area-served, population-served, and population change analyses.

Two of the main goals of the national PAMS network assessment were to (1) assess data quality and (2) determine how well the PAMS sites are currently serving their objectives. That is, are PAMS sites actually meeting Type 1, 2, 3, and 4 site objectives? One of the key analyses involved an examination of PAMS Type 3 (maximum ozone concentration) sites to determine if they are still capturing maximum ozone concentrations given changes in population and emissions patterns over time. For this analysis, all (or most) ozone sites were considered including both PAMS and non-PAMS ozone sites as well as sites located both inside and outside the SJV. Area-served analyses were not performed for the PAMS assessment because the PAMS network design is based primarily on siting monitors relative to urban centers to characterize upwind, maximum, and downwind pollutant concentrations and transport rather than maximum spatial coverage.

2.3.2 Key Findings and Discussion of the PAMS Network Assessment

The findings from the data completeness and percent above MDL analyses indicate that the quality of select VOC species measured at the PAMS SJVUAPCD-operated sites is generally poor. The MDLs throughout the region are high, and despite high observed concentrations, more than 50% of measurements (for some species) are reported below the MDL. Despite the MDL issue, all the sites in the SJV appear to be suitable for long-term trends analysis of ozone, total non-methane organic compounds (TNMOC), and some ozone precursors (i.e., benzene, toluene, etc.).

The SJV is classified as “serious” for ozone nonattainment. Based on the analysis of maximum concentrations, the SJV reported some of the highest ozone concentrations and precursor concentrations in the United States. **Figure 2-18** shows the average number of days per year in 2004–2006 when the 8-hr daily maximum ozone concentrations were greater than 75 ppb in Central California. **Figure 2-19** shows the average number of days per year that sites in the SJV and nearby nonattainment areas reported maximum ozone concentrations greater than 75 ppb. Note that both PAMS and non-PAMS ozone sites were included in this analysis to help identify if PAMS Type 3 sties are capturing areas of high (or maximum) ozone concentrations.

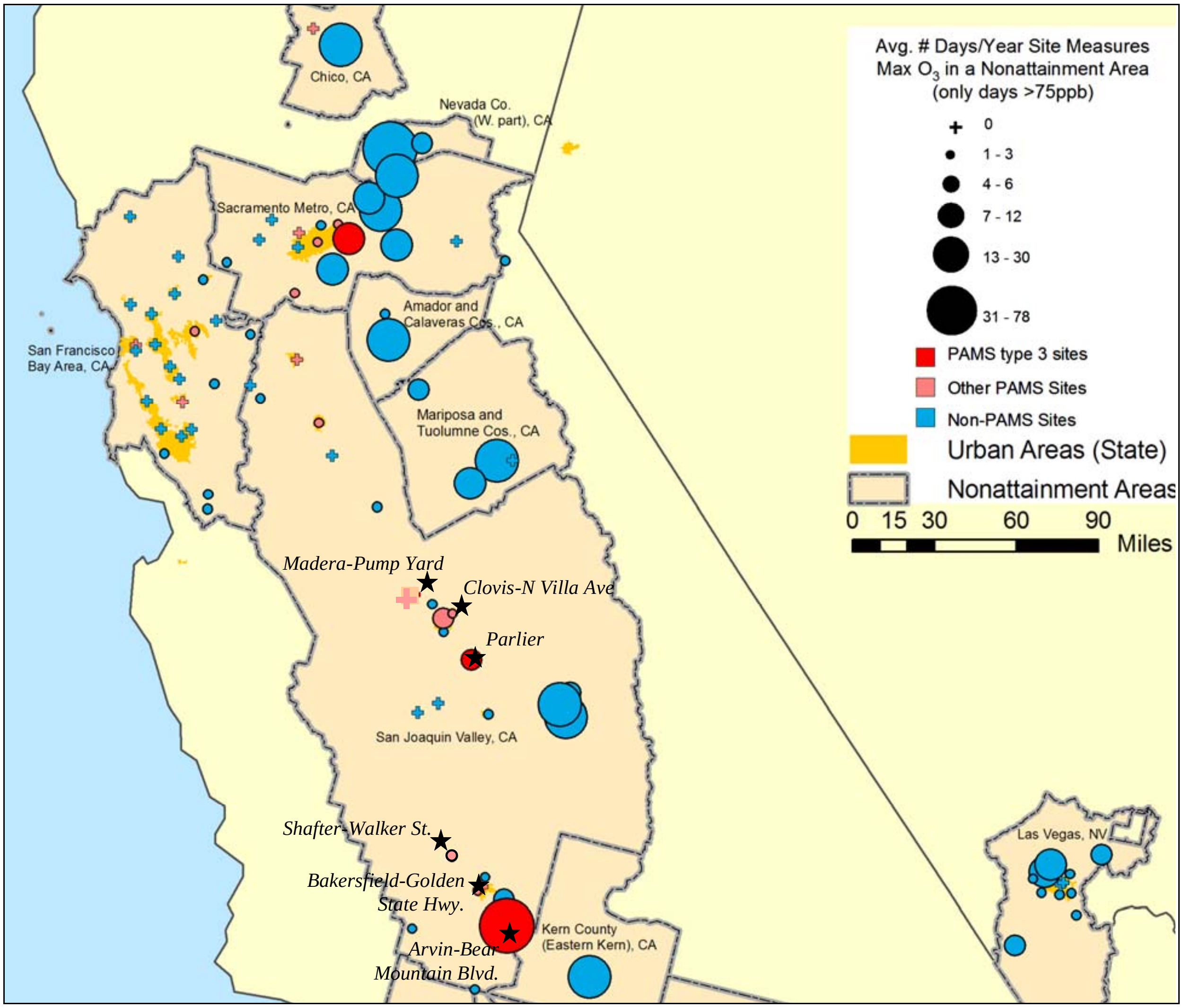


Figure 2-18. Average number of days per year when 8-hr daily maximum ozone concentrations were greater than 75 ppb from 2004 through 2006 in Central California. Note that this analysis included both PAMS and non-PAMS ozone sites both within and outside of the SJV. Stars indicate the PAMS sites operated by the SJVUAPCD.

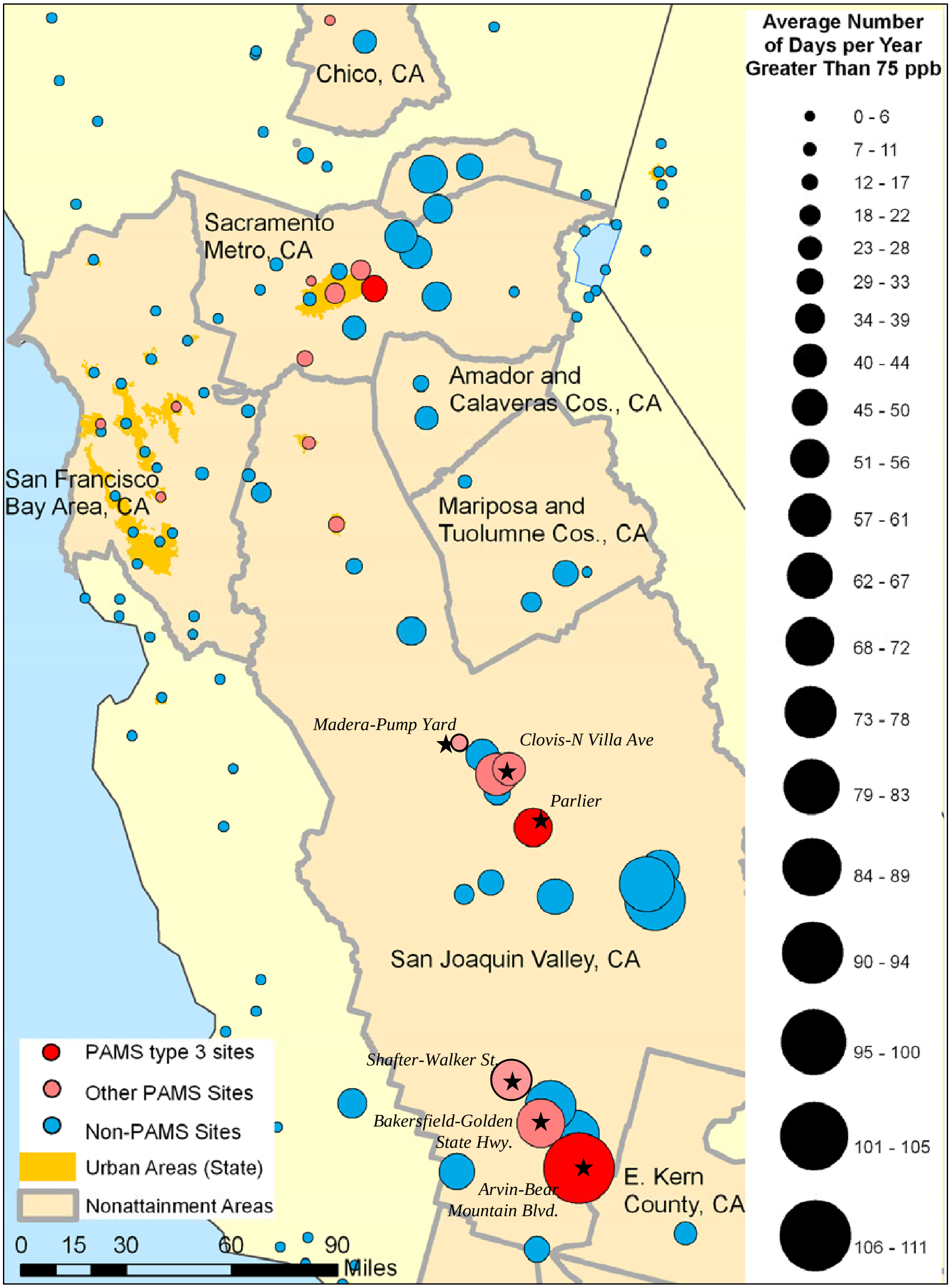


Figure 2-19. Average number of days a site reported 8-hr daily maximum ozone concentrations greater than 75 ppb in the SJV and nearby nonattainment areas. Note that the sites indicated with stars are operated by the SJVUAPCD.

One of the most notable findings from the PAMS network assessment is that Arvin and Parlier are designated as Type 3 sites, or sites that measure maximum ozone concentrations. The Arvin site appears to be accurately located to meet the Type 3 monitoring objectives; however, the Parlier site does not appear to be far enough downwind to capture the highest ozone concentrations. Due to changes in emissions patterns, the chemical composition of ozone precursors, and population growth, locations of maximum ozone concentrations have shifted over time and now generally occur along the foothill region on the eastern side of the SJV. These changes provide more evidence that the area northeast of Clovis may warrant an additional ozone monitor. The objectives of the PAMS site at Parlier should be reassessed and changed to reflect shifts in population, emissions patterns, and precursor chemistry because this site may no longer be serving its objectives; alternatively, the site could be relocated to the southeast of Fresno to better capture the maximum ozone concentrations along the foothill region. Site-specific observations are provided in **Table 2-18**.

Table 2-18. Site-specific observations for the PAMS sites operated by the SJVUAPCD.

PAMS Site Type	Current Site	Analysis Comments
1/2	CA – Madera	Improve data quality; site consistent with objectives.
	CA – Shafter	Improve data quality; site consistent with objectives.
2	CA – Bakersfield	Highest local concentrations; consistent with Type 2 site characteristics; improve data quality.
	CA – Clovis Villa	High VOC, somewhat low NO_x concentrations, low predicted emissions; evaluate if site best meets Type 2 characteristics.
3	CA – Arvin	Improve data quality; high ozone site, consistent with Type 3 objectives.
	CA – Parlier	Improve data quality; consider relocating site to the southeast of Fresno or changing the site designation to Type 2.

The PAMS network design was developed specifically to characterize upwind, fresh emissions, and downwind pollutant concentrations within a region for the purpose of understanding ozone precursor emissions, chemical transformation, ozone patterns, and transport. PAMS sites are not specifically sited to monitor population exposure. Therefore, the area- and population-served analysis results are useful for determining the extent of spatial coverage of each site and which PAMS sites might also be candidate sites for monitoring population exposure. **Table 2-19** shows the area, population, and population change results for the SJVUAPCD-operated PAMS sites. Based on the area- and population-served results, Clovis could be a candidate PAMS site for examining population exposure to ozone and ozone precursors.

Table 2-19. Summary of the area-served, population-served, and population change analyses for the SJVUAPCD PAMS monitoring network. Red dots represent the high-ranking sites, green dots represent the mid-ranking sites, and blue dots represent the low-ranking sites.

Site Name (showing SJVUAPCD-operated sites only)	**Area Served**	**Population Served**	**Population Change**
Madera–Pump Yard	● (red)	● (green)	● (green)
Clovis–N Villa Avenue	● (green)	● (red)	● (green)
Parlier	● (green)	● (green)	● (green)
Shafter–Walker Street	● (green)	● (blue)	● (blue)
Bakersfield–GSH	● (green)	● (green)	● (red)
Arvin–Bear Mountain Blvd	● (blue)	● (blue)	● (blue)

• (red) Highest ranking sites (e.g., largest area-/population-/etc.-served value): Top 25% of all sites within the analysis
• (green) Middle ranking sites: 25%-75% of all sites within the analysis
• (blue) Lowest ranking sites (e.g., smallest NO_x emissions value): Bottom 25% of all sites within the analysis
Total PAMS monitoring sites included in this analysis = 8

3. TECHNICAL APPROACH AND FINDINGS OF THE METEOROLOGICAL NETWORK ASSESSMENT

Accurate representation of the spatial and temporal characteristics of a region's meteorology is needed to understand the physical and chemical processes that influence air quality to help determine ways to mitigate future air quality impacts. The main meteorological conditions that influence air quality include: transport of pollutants by winds, recirculation of air by local wind patterns, horizontal dispersion of pollution by wind, variations in sunlight due to clouds and seasons, vertical mixing and dilution of pollution within the atmospheric boundary layer, temperature, and moisture. These conditions are typically measured by a network of surface meteorological stations, weather balloons, and remote sensing equipment such as radar wind profilers (RWPs) and sodars.

The SJVUAPCD has been monitoring meteorology for many years to support the ambient air monitoring programs. **Figure 3-1** shows a map of the (a) upper-air and (b) surface meteorological sites operated by the SJVUAPCD and sites operated by the National Oceanic and Atmospheric Administration (NOAA). While data from the meteorological network support a variety of air quality analysis applications, one of the primary uses of the meteorological data is to aid in the daily forecasting of weather conditions and air quality (San Joaquin Valley Air Pollution Control District, 2008).

The goals of the meteorological network assessment presented in this section were to determine the network's ability to represent the critical and important meteorological conditions in the SJV and to assess the network's ability to provide information to support weather and air quality forecasting and State Implementation Plan (SIP) development designed to reduce pollution in the SJV. In particular, analyses were performed to address the following questions:

- Does the surface monitoring network capture the spatial and temporal variability of winds, temperature, and humidity?
- Do the aloft measurements and data capture spatial and temporal characteristics of the aloft winds, temperature, and mixing heights in the region?
- Are there redundant sites?

The remainder of this section describes the technical approach and findings of the meteorological network assessment.

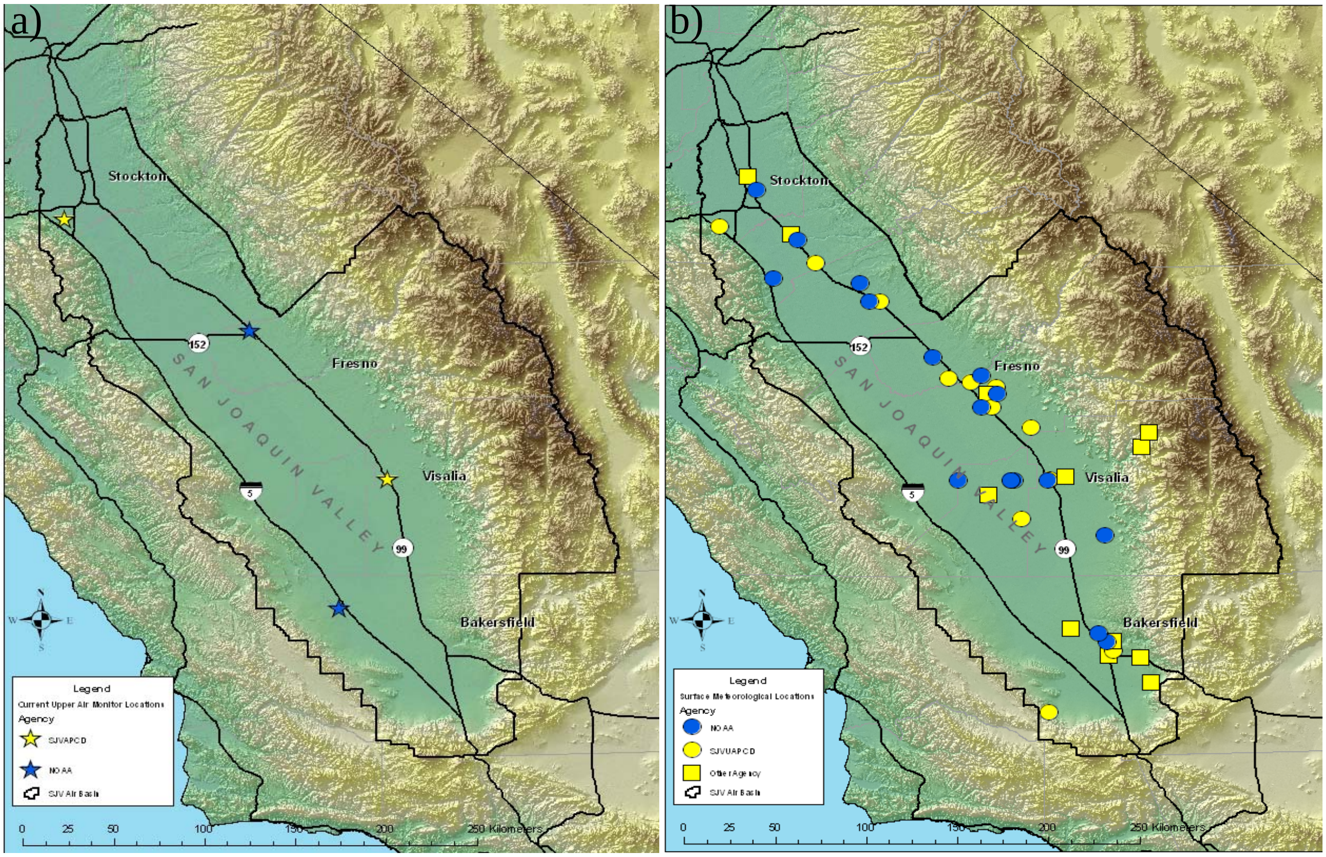


Figure 3-1. (a) Map of upper-air meteorological sites operated by the SJVUAPCD (yellow stars) and NOAA (blue stars) for the period 1998 through 2002; (b) map of surface meteorological sites operated by the SJVUAPCD (yellow circles), NOAA (blue circles), and other agencies (yellow squares) in the SJV.

3.1 SURFACE NETWORK ASSESSMENT

To evaluate the surface meteorological network, STI reviewed surface meteorological data collected in and within 20 miles of the SJV for the period 1998–2002. The data included wind speed, wind direction, temperature, relative humidity, and dew point temperature data. These data were obtained from the EPA's AQS and the NOAA's National Weather Service Meteorological Terminal Air Report (METAR) network. The AQS data were collected at sites operated by the CARB, SJVUAPCD, National Park Service (NPS), or jointly by CARB and SJVUAPCD.

STI used data from 1998–2002 because the SJVUAPCD's wind data collected during 2003–2008 were not valid. In addition, STI determined that the meteorological network for the 1998–2002 period contained no substantial differences from the current network; therefore, the results from the analysis of data from 1998–2002 provide a valid assessment of the current network. The METAR sites were considered in this evaluation because they provide reliable, quality controlled data on a permanent basis. The Remote Automated Weather Stations (RAWS) meteorological data network also operates many monitors in and around the SJV; however, many of these are run seasonally and the data are not subject to regular or consistent quality control. Therefore, this network was not considered in this evaluation and analysis.

Using these data, STI

- Determined data completeness and percent of valid data reports for temperature, relative humidity, dew point temperature, wind speed, and wind direction for each site. This was done to assess the overall quality of the data provided by the network.
- Created spatial wind rose plots to identify (1) important meteorological flow patterns and (2) regions that need monitors to capture the important meteorological phenomena in and around the SJV basin.
- Calculated site-to-site correlations for each meteorological variable (temperature, relative humidity, dew point temperature, and wind speed) to help determine if there were redundant sites. METAR sites were evaluated separately because these sites are not operated by the SJVUAPCD.

3.1.1 Data Completeness

Data completeness was calculated by dividing the number of samples reported by the total number of samples expected based on an hourly sampling frequency. In general, a robust data set will have at least 85% completeness. The percent of valid data samples was calculated by dividing the number of valid data records by the total number of data records. It is important to identify the percent of valid data samples because a data set might be very complete but have mostly invalid data. **Table 3-1** shows a summary of the results of the data completeness and percent valid analyses by parameter for all sites in the SJV air basin and sites from surrounding air basins, and shows the operator of each site.

Table 3-1. Data completeness and percent of valid data reports for each site in the SJV air basin and sites from surrounding air basins. Yellow highlighted cells indicate data completeness below an 85% target and orange highlighted cells indicate percent valid below 80%.

		Relative Humidity		Dew Point Temperature		Temperature		Wind Speed		Wind Direction	
Site Name	Site Operator	Data Completeness (%)	% Valid	Data Completeness (%)	% Valid	Data Completeness (%)	% Valid	Data Completeness (%)	% Valid	Data Completeness (%)	% Valid
Corcoran	SJVUAPCD	Not Reported		Not Reported		100	82	100	96	100	98
Bakersfield Golden State Highway	SJVUAPCD	98	96	Not Reported		98	96	80	72	80	72
Turlock S Minaret Street	SJVUAPCD	Not Reported		Not Reported		Not Reported		35	33	35	33
Madera Pump Yard	SJVUAPCD	Not Reported		Not Reported		100	99	95	94	95	94
Maricopa Stanislaus Street	SJVUAPCD	Not Reported		Not Reported		99	98	76	75	76	75
Clovis - N. Villa Ave	SJVUAPCD	100	89	Not Reported		100	99	35	35	35	35
Parlier	SJVUAPCD	100	98	Not Reported		100	99	40	39	40	39
Merced S. Coffee Ave	SJVUAPCD	Not Reported		Not Reported		100	100	40	40	40	40
Fresno Sierra Skypark	SJVUAPCD	Not Reported		Not Reported		100	100	100	100	100	99
Visalia Airport	SJVUAPCD	85	80	Not Reported		85	84	85	84	85	84
Sequoia NP Lower Kaweah	NPS	98	95	Not Reported		100	96	100	95	100	95
Sequoia and Kings Canyon Natl Park	NPS	23	21	Not Reported		23	21	23	23	23	23
Fresno 1st Street	CARB	91	90	Not Reported		97	95	96	96	95	95
Arvin Bear Mountain Blvd	CARB	95	94	Not Reported		90	90	100	100	90	90
Bakersfield 5558 California Ave	CARB	100	98	Not Reported		95	93	100	97	100	97
Edison	CARB	Not Reported		Not Reported		100	99	100	99	100	99
Oildale 3311 Manor Street	CARB	Not Reported		Not Reported		98	97	100	99	100	99
Stockton Hazelton Street San Joaquin	CARB	98	95	Not Reported		98	97	98	97	98	97
Modesto 14th Street	CARB	Not Reported		Not Reported		93	92	93	93	93	93
Visalia N Church Street	CARB	Not Reported		Not Reported		100	100	100	100	100	100
Shafter Walker Street	CARB	30	30	Not Reported		100	99	100	100	100	100
Pt. Piedras Blanco	NOAA	Not Reported		97	99	97	99	97	99	97	99
Napa	NOAA	Not Reported		95	95	95	95	95	98	95	98
Auburn Muni	NOAA	Not Reported		3	100	3	100	3	100	3	100
Bakersfield	NOAA	Not Reported		97	100	97	100	97	98	97	98
Bishop	NOAA	Not Reported		98	100	98	100	98	96	98	96
Concord	NOAA	Not Reported		87	99	87	100	87	98	87	98
Edwards Afb	NOAA	Not Reported		80	99	80	100	80	92	80	91
Fresno	NOAA	Not Reported		97	100	97	100	97	97	97	97
Hanford	NOAA	Not Reported		89	98	89	98	89	96	89	96
Hanford/San Joaq	NOAA	Not Reported		6	0	6	0	6	0	6	0
Hayward	NOAA	Not Reported		93	99	93	100	93	99	93	99
Inyokern	NOAA	Not Reported		29	4	29	99	29	89	29	88
Livermore	NOAA	Not Reported		96	97	96	97	96	98	96	98
Madera	NOAA	Not Reported		79	98	79	98	79	97	79	97
Mcclellan Afb	NOAA	Not Reported		55	99	55	99	55	99	55	99
Merced	NOAA	Not Reported		89	99	89	99	89	98	89	97
Mather Field	NOAA	Not Reported		43	98	43	99	43	99	43	99
Mojave	NOAA	Not Reported		30	3	30	99	30	96	30	95
Mammoth/June Lak	NOAA	Not Reported		30	95	30	99	30	98	30	98
Modesto	NOAA	Not Reported		94	99	94	99	94	98	94	98
Monterey	NOAA	Not Reported		97	99	97	99	97	98	97	98
China Lake (Naf)	NOAA	Not Reported		47	99	47	100	47	95	47	95
Lemoore Nas/Reev	NOAA	Not Reported		60	100	60	100	60	97	60	97
Moffett Nas/Mtn	NOAA	Not Reported		98	100	98	100	98	98	98	98
Oakland	NOAA	Not Reported		98	100	98	100	98	99	98	99
Palo Alto	NOAA	Not Reported		60	98	60	99	60	93	60	92
Paso Robles	NOAA	Not Reported		95	100	95	100	95	97	95	97
Porterville	NOAA	Not Reported		92	100	92	100	92	100	92	100
San Jose/Reid	NOAA	Not Reported		64	98	64	98	64	96	64	95
Sacramento	NOAA	Not Reported		98	100	98	100	98	98	98	97
San Luis Obispo	NOAA	Not Reported		97	100	97	100	97	98	97	98
Stockton	NOAA	Not Reported		97	100	97	100	97	98	97	98
San Francisco	NOAA	Not Reported		98	100	98	100	98	100	98	99
San Jose	NOAA	Not Reported		98	100	98	100	98	98	98	98
Sacramento/Metro	NOAA	Not Reported		98	100	98	100	98	98	98	98
Santa Maria	NOAA	Not Reported		98	100	98	100	98	98	98	98
Salinas	NOAA	Not Reported		98	100	98	100	98	99	98	99
San Carlos Airpo	NOAA	Not Reported		60	98	60	99	60	95	60	94
Sacramento/Wfo	NOAA	Not Reported		3	0	3	0	3	0	3	0
Travis Afb/Fairf	NOAA	Not Reported		95	100	95	100	95	96	95	95
Vacaville	NOAA	Not Reported		81	100	81	100	81	95	81	94
Visalia Muni	NOAA	Not Reported		82	100	82	100	82	100	82	100
Watsonville	NOAA	Not Reported		83	99	83	99	83	96	83	96

Table 3-1 shows that of the 64 total sites in the SJV, only 39 sites (14 AQS sites and 25 METAR sites) had 85% data completeness for temperature, wind speed, wind direction, and dew point temperature or relative humidity. Findings for the sites operated by SJVUAPCD, CARB, or NPS, shown in Table 3-1**,** are as follows:

- At all sites, parameters with high data completeness also had a high percentage of valid data.
- Temperature data completeness and percent of valid data were high for all but one site.
- Relative humidity data completeness and percent of valid data were high for 9 of 11 sites.
- Wind speed and direction data completeness and percent of valid data were high for 14 of 21 sites.

3.1.2 Wind Rose Analyses

A meteorological monitoring study recently performed for the SJV recommended that the monitoring network in the SJV should adequately resolve the following phenomena (Sweet et al., 2002):

- Sea breeze and marine air intrusion
- Marine fog and stratus
- Mixing depth/inversion strength
- Upslope/downslope flows
- Bifurcation of the delta flow
- Eddies and jets
- Flows over mountain passes
- Synoptic deformation, subsidence

The ability of the meteorological data network to represent the spatial and temporal variations of the sea breeze and marine air intrusion, upslope/downslope flows, bifurcation of the delta flow, and flows over mountain passes was evaluated using spatial plots of wind roses placed on a map of the SJV. Wind roses show the frequency of winds blowing from compass-based directions and provide a view of the distribution of wind speed and direction at a particular site. The seasons were selected to approximately capture periods that are more conducive to high $PM_{2.5}$ concentrations, i.e., November through March, and high ozone concentrations, i.e., April through October. Wind roses were created for the following four time periods:

1. warm-season day (6:00 a.m. through 5:59 p.m. April through October)
2. warm-season night (6:00 p.m. through 5:59 a.m. April through October)

3. cool-season day (6:00 a.m. through 5:59 p.m. November through March)
4. cool-season night (6:00 p.m. through 5:59 a.m. November through March)

Wind roses were created for surface meteorological sites that had at least 85% data completeness and 80% valid data.

In summary, analysis of the wind roses for the four time periods adequately capture some of the phenomena listed above, but not all. (Note, only figures of wind roses for the central valley that provide critical information about the flow regimes in the SJV are shown in this report.) Key observations include:

- The surface meteorological network adequately captures the sea breeze and marine air intrusion in most areas; however, adding a surface meteorological site in the delta would improve information about the strength and timing of the delta breeze.
- The surface meteorological network adequately captures the upslope/downslope flows along the east side of the SJV and around Bakersfield (**Figures 3-2a and 3-2b**), as shown as the oscillation between upslope flow during the day and downslope flow overnight. However, additional surface meteorological sites east of Visalia, Fresno, and Modesto at the base of the Sierra Nevada foothills would help to better capture this phenomenon. The network is not adequate along the west side of the SJV (**Figure 3-2b**). Adding two to three sites along the western SJV would help to better capture the upslope/downslope flows occurring on the western edge of the SJV, which would also help forecasters assess transport to and from coastal areas.
- The surface meteorological network adequately captures bifurcation of the delta flow (**Figure 3-3**) as shown by the predominant southerly winds in the extreme northern SJV and northerly winds near Modesto; however, adding a site in the delta near Discovery Bay would better capture the southern branch of the delta breeze.
- The surface meteorological network does not appear to adequately capture flows over mountain passes. Adding sites near the east end of the Pacheco Pass and at the north end of the Tehachapi and Tejon Passes would help better capture transport into and out of the SJV. It should be noted that the Kern County Air Pollution Control District recently added an air quality and meteorological site at the southeastern end of the SJV domain. These data could be used to fill in potential monitoring gaps in this area.

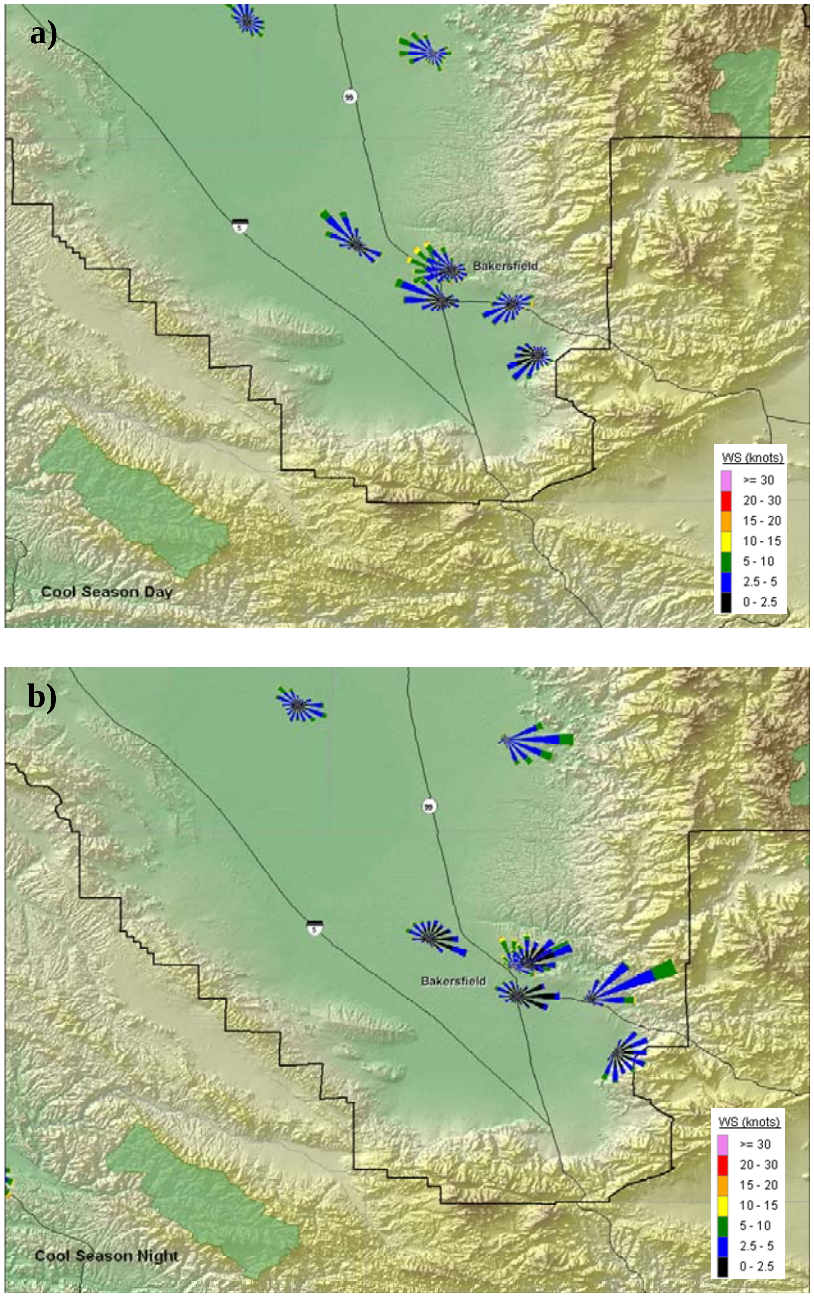


Figure 3-2. (a) Cool-season day and (b) cool-season night wind roses for SJVUAPCD- and NOAA-operated sites in the southern SJV near Bakersfield. Calm wind measurements are not included in these plots.

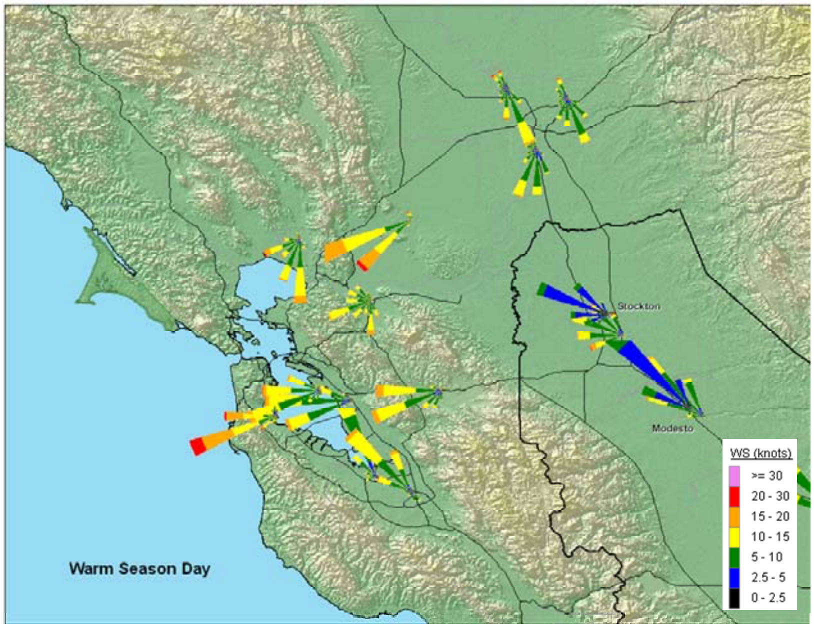


Figure 3-3. Warm-season day wind roses for sites operated by SJVUAPCD and NOAA for the northern SJV. Note the current network also includes a site at Tracy Airport (not shown). Calm wind measurements are not included in these plots.

3.1.3 Site-to-Site Correlation Analyses

To identify possible redundancies in the surface meteorological network, correlation analyses were performed for temperature, relative humidity, dew point temperature, and wind speed. High correlation between sites for all parameters could indicate redundancy in the monitoring network. The Pearson correlation coefficient (R) between site pairings indicates how well the data agree. The R value is a measure of the linear relationship between two variables and ranges from -1.0 to 1.0. An R value of 1.0 means that there is a positive linear relationship between two variables (i.e., when the measurement of interest at one site is high, it will also be high at the other site); which indicates that the two sites agree well and could possibly be redundant. It is highly unlikely that there will be a perfect correlation between two sites; however, if the data from two sites are plotted against one another a higher R value indicates that there is a stronger correlation between sites, which could indicate a potential site redundancy.

Correlations were computed using hourly data from 1998 through 2002 for the AQS and METAR surface sites with greater than 85% percent data completeness and greater than 80% valid data. In general, correlations for temperature are good with an average R value of 0.89, which is expected since temperatures within a geographically similar area should be relatively similar. The correlations are much lower for the Sequoia National Park Lower Kaweah site (average R value of 0.61); however, this is also expected since this site is located in the mountains and is in a different geographic area. The wind speed correlations were, on average, 0.42, with sites located near one another having slightly higher correlations, but none as high as 0.89. This indicates that while temperature measurements suggest potential site redundancies, wind correlations do not; thus, the AQS sites are not redundant. Similar to the AQS sites, wind speed correlations for the METAR sites were much lower than temperature correlations, averaging 0.47 for wind speed compared to 0.80 for temperature; indicating no site redundancies for the METAR sites. METAR sites were evaluated separately because these sites are not operated by the SJVUAPCD.

3.2 UPPER-AIR NETWORK ASSESSMENT

Many detailed analyses have investigated the upper-air data needs for the SJV. Rather than repeating this work, STI reviewed the results from these past studies and provided recommendations about the most effective ways to improve the upper-air network, as well as a prioritized list of additions or changes to the network. For this evaluation, we considered RWPs operated by SJVUAPCD and NOAA. SJVUAPCD operates two permanent RWP sites, one in Visalia and one in Tracy (yellow stars in Figure 3-1). NOAA operates two temporary sites, one in Lost Hills and one in Chowchilla (blue stars in Figure 3-1); both of the NOAA sites are planned to be decommissioned in 2010. Because RWPs are complex instruments, STI also reviewed recent RWP data from SJVUAPCD to determine whether the profilers are providing data of sufficient quality.

Two studies performed for the SJV identified several important upper-air meteorological phenomena that contribute to air quality in the SJV (Roberts et al., 1990; Sweet et al., 2002). The key meteorological phenomena in the SJV are described below along with a discussion of the ability of the current upper-air network to capture these phenomena.

- The **Fresno eddy** is an elongated cyclonic circulation between Delano and Fresno with an east-west center near, or slightly west of, Highway 99. The eddy circulation develops about midnight and reaches a maximum stage at 0900 PDT. The eddy transports carryover pollutants and fresh morning emissions northward to Visalia and Fresno. These pollutants are entrained to the surface in the late morning when the mixed layer grows. Thus, the Fresno eddy is important for evaluation of potential pollution re-circulation. The Visalia and Chowchilla RWPs are in good locations to capture the Fresno eddy. Extending the operation of the Chowchilla site is recommended.
- The **nocturnal jet** is a low-level nocturnal jet that forms regularly during summer nights in the SJV. The nocturnal jet is strongest along the west side of the SJV. The formation of the nocturnal jet and Fresno eddy are probably linked because the eddy never appeared unless the jet was present the previous night. The Tracy and Lost Hills RWPs are in good locations to capture the nocturnal jet; therefore, extending the operation of the Lost Hills site is recommended.
- **Marine intrusion**. Marine air regularly invades the SJV and may have a significant diluting effect on pollutants and/or pollution transport from the San Francisco Bay Area (SFBA). Pollutants may even be transported from the SJV

toward the coast under some circumstances. The current RWP network moderately captures the marine intrusion; however, continued operation of the Lost Hills site and the addition of sites near Pacheco Pass and Discovery Bay are recommended.

- **Mixing depths.** Information about mixing depth/inversion strength is important for determining potential pollution dilution due to vertical mixing. Mixing depths vary throughout the valley, and the upper-air network should be able to capture this variation. Adding an RWP site near Bakersfield to the current network (including the NOAA RWPs) would better capture the mixing depth variation throughout the valley. SJVUAPCD should also consider new remote sensing technology, such as ceilometers, for determining mixing heights. For example, software is currently being developed to automatically derive mixing heights from ceilometer data.

3.2.1 Data Quality

STI evaluated the current quality of the RWP data from the permanent site run by the SJVUAPCD at Tracy. STI did not evaluate the Visalia RWP due to an in-progress equipment upgrade. STI reviewed RWP data for April 14, 2009, through May 15, 2009. In particular, STI reviewed the moments, winds, and the Radio Acoustic Sounding System (RASS) virtual temperature data. The results of this analysis are presented below:

- The moments data were of good quality; however, STI recommends the addition of an automated boundary layer algorithm.
- The wind data had good height recovery with maximum height recoveries of approximately 3300 m above ground level (agl); however, there were some outliers.
- The RASS virtual temperature data height recovery was a little low. Therefore, STI recommends checking
    a. the true root mean square (RMS) voltage at the audio amplifier outputs. The reading should be above 19V and should not exceed 24V; and
    b. the audio levels of each RASS source. The audio levels typically range between 115 to 120 dB.

Additionally, regularly performing quality control on all RWP and RASS data by implementing real-time quality control algorithms would provide data of better quality and reduce outliers. These algorithms may remove some of the outliers, minimize time spent on quality control, and potentially result in better data recovery.

4. RECOMMENDATIONS AND DISCUSSION

This section contains a summary of the synthesized findings, recommendations, and discussion for the air monitoring and meteorological networks in the SJV. The recommendations in this section should be viewed in light of agency monitoring objectives, priorities, and resources. In addition, the recommendations provided in this section assume that the CARB will continue to operate existing sites in the SJV.

4.1 SUMMARY OF RECOMMENDATIONS FOR THE AIR MONITORING NETWORK

Criteria Pollutant Network

- Overall, the monitoring site coverage in the SJV is robust along the central north-to-south corridor. However, gaps appear along the western and eastern region for specific pollutants including ozone, $PM_{2.5}$, PM_{10}, and NO_2. Populated and unmonitored areas more than 50 km away from existing monitors are of concern. Unless the SJVUAPCD has special study data indicating low spatial variability in pollutant concentrations in the areas that lack monitors, then additional sites in these unmonitored regions should be considered. The SJVUAPCD should consider adding two additional criteria sites in the region west of Merced (Los Banos area) and in the region northeast of Clovis, where there appear to be gaps in the network.
- The area between Corcoran and Bakersfield may warrant an additional $PM_{2.5}$ 1-hr continuous monitoring site based on population density and PM emissions levels. Again, further investigation of the spatial variability in $PM_{2.5}$ concentrations observed in special studies should be performed (if available) in this area prior to installing a site to determine if the site would add value.
- Assuming that high-sensitivity CO instruments are going to replace existing CO instruments, further analyses should be performed using CO data from the Fresno sites to identify potentially redundant CO monitors.

PAMS Network

- One SJVUAPCD-operated PAMS site in the SJV, Parlier, is designated as a Type 3 maximum ozone concentration site; however, this site does not appear to be appropriately located to monitor maximum ozone concentrations. The SJVUAPCD should consider either (1) changing the site-type designation or (2) relocating the site to better reflect the site objectives.
- California Alternate Plan sites do not measure TNMOC and only measure NO_x concentrations, leaving substantial holes in the SJV monitoring network.
- Lower MDLs for VOCs are achievable and may make the monitoring data more useful for analysis efforts.

- Additional or repurposed monitors in the Sierra Nevada Foothills may be appropriate to capture peak ozone in the SJV.

4.2 SUMMARY OF RECOMMENDATIONS FOR THE METEOROLOGICAL MONITORING NETWORK

General Recommendations

- A general network recommendation is that all air quality monitors that collect temporally resolved data (i.e., hourly) should have collocated meteorological instruments to measure temperature, winds, relative humidity, and solar radiation. The SJVUAPCD has already implemented this recommendation.
- Not all meteorological sites need air quality measurements; however, meteorological sites located in transport corridors should measure ozone, NO_x, and $PM_{2.5}$ (preferably collected on an hourly basis).

Surface Meteorological Network

- Adding a surface meteorological site in the delta near Discovery Bay would improve information regarding the strength and timing of the southern branch of the delta breeze. This information could be used to help assess transport from the San Francisco Bay Area into the SJV.
- Adding surface meteorological sites east of Visalia, Fresno, and Modesto at the base of the Sierra Nevada foothills would improve information regarding the oscillation between upslope flow during the day and downslope flow overnight. This information can be used to help assess local-scale pollutant recirculation. A recommendation from the air monitoring network assessment is to add a criteria pollutant site to the area northeast of Clovis. Deploying a criteria pollutant monitoring site with collocated meteorological measurements northeast of Clovis would serve both the air and meteorological networks.
- Adding two to three sites along the western SJV would help to better capture the upslope/downslope flows in and out of the Coast Range and the flows to and from coastal areas. General locations to consider include the east end of Pacheco Pass between Tranquility and Tracy and west of Interstate 5, Kettleman City, Lost Hills, and/or Coalinga. A recommendation from the air monitoring network assessment is to add a criteria pollutant site to the area west of Merced (Los Banos area). Deploying a criteria monitoring site with collocated meteorological measurements at the east end of the Pacheco Pass would serve both the air quality and meteorological networks.
- Adding sites near the east end of the Pacheco Pass and at the north and south ends of the Tehachapi and Tejon Passes would provide information to better capture transport in and out of the SJV in these areas. Any added sites should include ozone and $PM_{2.5}$ measurements.
- Correlation analyses indicated that there are no redundant meteorological sites.

Upper-air Meteorological Network (General)

- The RWP at Chowchilla should continue operation to provide data to capture the depth, timing, and strength of the Fresno eddy.
- The RWP at the Lost Hills site should continue operation to capture the depth, timing, and strength of the nocturnal jet. The nocturnal jet strongly influences transport of pollutants from the SFBA and within the SJV.
- The current RWP at Tracy captures the marine intrusion along the Altamont Pass; however, continued operation of the Lost Hills site and adding sites near Pacheco Pass and Discovery Bay would capture the spatial variations of the marine intrusion through key corridors. The information would help determine (1) transport to and from coastal areas and (2) the timing of conditions that tend to move pollution out of the SJV.
- Adding a RWP site near Bakersfield would be useful to provide information regarding the aloft winds, stability, and mixing depth in the southern end of the SJV. A site near Bakersfield combined with the current RWP network (including Lost Hills and Chowchilla) would help capture the temporal and spatial variations of mixing depth throughout the valley.

Upper-air Meteorological Network (Data Quality)

The following recommendations will help improve data quality from the upper-air network:

- Add automated mixing height detection algorithm to all RWP instruments.
- The RASS virtual temperature data height recovery was a little low. Therefore, STI recommends checking (1) the true RMS voltage at the audio amplifier outputs (the reading should be above 19V and should not exceed 24V) and (2) the audio levels of each RASS source. The audio levels typically range between 115 to 120 decibels.
- Perform quality control on all RWP and RASS data on a regular basis by implementing real-time quality control algorithms.

4.3 DISCUSSION

This section provides a discussion of the questions (Section 1) that SJVUAPCD sought to address with the results of this network assessment.

Which sites provide the most value in terms of the number of pollutants measured, the length of data record, and data quality?

The Clovis, Bakersfield–GSH, Tracy, Turlock, Fresno–Sierra Skypark #2, and Fresno–Drummond sites provide the most value in terms of the number of criteria pollutants measured. These sites all provide good criteria pollutant data quality. The PAMS sites—Madera, Clovis, Parlier, Shafter, Bakersfield–GSH, and Arvin—also provide value in terms of the number of parameters measured; however, the PAMS VOC data quality for some species at these sites needs improvement. While all PAMS data collection efforts may be meeting minimum requirements for VOC measurements and reporting, these minima are inadequate, resulting in a large amount of data reported below the MDL. It has been recommended to EPA that the national-scale requirements for MDL values, which are achievable, should be strengthened to reflect the lower precursor concentrations routinely observed (McCarthy et al., 2008). Lower MDLs would make the VOC data more useful for air quality analysis efforts.

The SJVUAPCD network has been in operation for many years and as a result has a generally long data record for performing trends analyses. The following sites are specifically valuable for assessing trends in ozone, ozone precursors, NO_2, and CO: Turlock, Merced, Madera, Fresno–Sierra Skypark, Clovis, Fresno–Drummond, Parlier, Shafter, Bakersfield–GSH, and Arvin. The following sites are specifically valuable for assessing trends in 24-hour PM_{10} concentrations: Stockton, Turlock, Merced, Clovis, Fresno–Drummond, Corcoran, and Bakersfield–GSH. The continuous PM network has not yet collected enough data to assess trends in hourly PM concentrations.

Are sites appropriately located to determine the highest pollutant concentrations expected to occur in the area covered by the network?

Yes, for primary pollutants such as VOCs, NO_x, PM_{10}, and CO that are directly emitted by sources along the central corridor of the SJV. However, for secondary pollutants—ozone and $PM_{2.5}$—there are likely gaps in the network along the downwind eastern side of the SJV and up into the Sierra Nevada foothills. Results of the national PAMS network assessment indicate that ozone concentrations often exceed the NAAQS at sites located in the foothill region. It is likely that the same meteorological phenomena and flow patterns that contribute to high ozone concentrations might also contribute to high $PM_{2.5}$ concentrations. Past studies should be reviewed and further data analysis should be performed to identify areas where maximum ozone and $PM_{2.5}$ concentrations are likely to occur.

The results of the national PAMS network assessment indicated that California has some of the highest concentrations of ozone precursor emissions and that this is particularly true in the SJV. The existing PAMS network is fairly robust for monitoring fresh emissions along the central corridor of the SJV. However, there appears to be an area of high emissions that is currently unmonitored west of Bakersfield.

Are sites appropriately located to measure typical pollutant concentrations in areas of high population density?

Yes, the existing network and planned modifications to the network adequately measure typical pollutant concentrations in the areas where population density is highest. The areas with the highest population densities are located along the central corridor of the SJV, and monitor coverage along this corridor is good. Two areas have moderate population densities and no monitors, and possibly high ozone and/or PM concentrations: (1) west of Merced (Pacheco Pass area) and (2) northeast of Clovis (Sierra Nevada Foothills).

Are sites appropriately located to determine the impact of significant sources or source categories on air quality?

In general, the existing and planned criteria pollutant monitoring network is adequate for determining the impact of broad-scale emissions sources (i.e., mobile sources) along the central corridor of the SJV, where most of the emissions occur. However, to capture the impacts of source-specific emissions, improvements in the monitoring network are needed. Specifically, additional instruments with time-resolved, speciated measurements could be strategically placed to measure the impacts of specific source categories. Additionally, special studies could be conducted to better understand emissions source activity and contributions. For example, time-resolved emissions activity data could be collected and/or special measurements could be made to further understand source contributions such as the relative contributions of on-road versus non-road emissions.

There appears to be a general gap in the $PM_{2.5}$ network along the central corridor between Corcoran and Bakersfield where PM emissions are relatively high. The PAMS network was established to measure ozone and ozone precursor emissions. There are high ozone precursor emissions in the northern end of the SJV and in the region to the west of Bakersfield. If the SJVUAPCD is considering relocating any PAMS sites, these are candidate areas for potential Type 2 site locations.

Are sites appropriately located to determine general background concentration levels?

There is substantial emissions activity within the SJV, particularly in the central SJV corridor along Highway 99 and Interstate 5. As a result, more background pollutant concentrations would be observed as one moved away from the central corridor to the east and west. There are currently general monitoring gaps along the eastern and western corridors of the SJV, specifically for $PM_{2.5}$ and PM_{10}. Two PM sites located east of the SJV in the Sierra Nevada mountain range could provide data to help characterize background concentrations of PM; however, no sites are located west of the central SJV corridor. Many sites along or outside the SJV study boundary could provide data that may be useful for determining general background ozone concentration levels.

Are sites appropriately located to determine the extent of regional pollutant transport among populated areas?

Existing sites are appropriately located to help determine the extent of regional pollutant transport. The addition of surface meteorological and collocated air quality sites near Discovery Bay, the east end of the Pacheco Pass, and the north end of the Tehachapi and Tejon Passes would provide information to help assess transport from the San Francisco Bay Area and to better characterize transport into and out of the SJV.

Are sites appropriately located to measure air pollution impacts on visibility, vegetation damage, or other welfare-based impacts and to support secondary standards?

In general, the objectives of the SJVUAPCD air monitoring network are geared toward monitoring high pollutant concentrations in populated areas, and most of the densely populated urban areas along the SJV central corridor have well equipped monitoring sites. As a result, the network is reasonably adequate for measuring welfare-based health impacts.

Visibility can be characterized by utilizing data currently collected in the network, but could also be better understood with additions to the network. PM is the main driver of visibility degradation, so using PM data, the visibility degradation could be estimated for each site currently in the network. Nephelometers or visibility cameras are also available, and could be deployed at multiple sites to obtain time resolved (i.e., hourly) visibility degradation information. Different particle types have different impacts on visibility, e.g., sulfate produces more degradation than organic carbon. Additional sites that measure speciated $PM_{2.5}$ data could be used to better understand the causes of visibility degradation.

The existing network has marginal value for measuring air pollution impacts on agriculture and natural vegetation. Some existing sites in the SJV, specifically those located in more rural areas, may be useful for measuring air pollution impacts on agricultural and natural vegetation. The addition of sites in the eastern and western regions of the SJV as recommended above could also help measure air pollution impacts on vegetation.

Are there potentially redundant sites in the network?

With the exception of the potentially redundant CO sites in the Fresno area, there do not appear to be any redundant sites in the air and meteorological network.

Are there new technologies that may add value to the air monitoring network?

In recent years, several types of monitoring equipment (including continuous PM2.5 instruments, CO2 monitors, and Aethalometers™) have become less expensive and easier to deploy and operate. The SJVUAPCD currently has plans to deploy additional continuous FEM PM2.5 instruments in the near future. The addition of CO2 monitors could be useful for understanding greenhouse gas (GHG) impacts in the SJV. The addition of Aethalometers™ to densely populated, urban areas could be useful for examining health impacts of black carbon.

Does the surface meteorological monitoring network capture the spatial and temporal variability of winds, temperature, and humidity? Are there gaps in the meteorological network? Are new sites or parameters needed to capture the spatial and temporal characteristics of meteorology to support air quality applications?

In general, the surface meteorological network adequately captures the spatial and temporal variability of winds, temperature, and humidity throughout the SJV. The addition of surface meteorological sites in the following locations would help augment the surface network: (1) near Discovery Bay, (2) along the base of the foothills on the eastern and western sides of the SJV, (3) near the east end of the Pacheco Pass, and (4) at the north end of the Tehachapi and Tejon Passes.

Do the aloft measurements and data capture spatial and temporal characteristics of the aloft winds, temperature, and mixing heights in the region?

The existing RWPs, including the two operated by NOAA at Lost Hills and Chowchilla, do an adequate job of capturing spatial and temporal characteristics of the aloft winds, temperature, and mixing heights in most of the SJV. However, the southern SJV lacks aloft meteorological information. Adding an RWP near Bakersfield would address this issue.

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APPENDIX A

SUMMARY OF SJVUAPCD-OPERATED AIR QUALITY SITES

Table A-1. A summary of the air quality monitoring sites included in the network assessment. Sites denoted with an asterisk (*) have collocated meteorological monitors.

Page 1 of 2

Site Type	Name	Parameters Measured	Sample Frequency	Site Objective
PAMS	Arvin – Bear Mountain Blvd (06-029-5001)*	OZONE NO NO_2 NO_x PAMS VOCs	1-hr/Continuous n/a 1-hr/Continuous n/a Canister 4/3/3	Rep. Conc. Empty Rep. Conc. Empty
PAMS/ SLAMS	Bakersfield–GSH (06-029-0010)*	OZONE NO_2 $PM_{2.5}$ PM_{10} CO [a] PAMS VOCs	1-hr/Continuous 1-hr/Continuous 1-hr & 24/X[b] 1-hr & 24/6 1-hr/Continuous Canister 4/3/3	Rep. Conc. High Conc. Rep. Conc. High Conc. Rep. Conc.
PAMS/ NAMS/ SLAMS	Clovis–N. Villa Ave (06-019-5001)*	OZONE NO_2 $PM_{2.5}$ PM_{10} CO[a] PAMS VOCs	1-hr/Continuous 1-hr/Continuous 1-hr & 24/X[b] 24/6 1-hr/Continuous Canister 4/3/3	High Conc. High Conc. Rep. Conc. Rep. Conc. Rep. Conc.
SLAMS	Corcoran (06-031-0004)*	OZONE[c] $PM_{2.5}$ PM_{10}	1-hr/Continuous 1-hr & 24/X[b] 1-hr & 24/3	High Conc. Rep. Conc. High Conc.
SLAMS/ NAMS	Fresno–Drummond Street (06-019-0007)*	OZONE NO_2 PM_{10} CO	1-hr/Continuous 1-hr/Continuous 24/6 1-hr/Continuous	High Conc. High Conc. Rep. Conc. Rep. Conc.
SLAMS	Fresno–Sierra Skypark (06-019-0242)*	OZONE NO_2 CO	1-hr/Continuous 1-hr/Continuous 1-hr/Continuous	Rep. Conc. Rep. Conc. Rep. Conc.
SLAMS	Fresno–Hamilton/Winery (06-029-5025)	$PM_{2.5}$	24/X[b]	Rep. Conc.
Special purpose	Huron (06-019-0000)	$PM_{2.5}$	1-hr/Continuous	Rep. Conc.

Table A-1 (continued). A summary of the air quality monitoring sites included in the network assessment. Sites denoted with an asterisk (*) have collocated meteorological monitors.

Site Type	Name	Parameters Measured	Sample Frequency	Site Objective
SLAMS	Hanford – S. Irwin Street (06-031-1004)	OZONE PM_{10}	1-hr/Continuous 24/6	 Rep. Conc.
	Lebec (06-037-9034)	OZONE $PM_{2.5}$	1-hr/Continuous 1-hr/Continuous	
PAMS/ SLAMS	Madera – Pump Yard (06-039-0004)*	OZONE NO_2 PAMS VOC	1-hr/Continuous 1-hr/Continuous Canister 4/3/3	Rep. Conc. Rep. Conc.
SLAMS	Maricopa – Stanislaus Street (06-029-0008)*	OZONE	1-hr/Continuous	High Conc.
SLAMS	Merced – 2334 M Street (06-047-2510)	$PM_{2.5}$ PM_{10}	24/X[b] 24/6	Rep. Conc. Rep. Conc.
SLAMS	Merced – S. Coffee Ave (06-047-0003)*	OZONE NO_2	1-hr/Continuous 1-hr/Continuous	High Conc. Rep. Conc.
PAMS/ SLAMS	Parlier (06-019-4001)*	OZONE NO_2 $PM_{2.5}$	1-hr/Continuous 1-hr/Continuous 1-hr/Continuous	High Conc. Rep. Conc.
NAMS	Stockton – Wagner/Holt (06-077-1002)	PM_{10}	24/6	Rep. Conc.
SLAMS	Tracy Airport (06-077-3005)*	OZONE PM_{10} $PM_{2.5}$ NO_2	1-hr/Continuous 1-hr/Continuous 1-hr/Continuous 1-hr/Continuous	Rep. Conc. Rep. Conc. Rep. Conc. Rep. Conc.
SLAMS	Turlock – S. Minaret Street (06-099-0006)*	OZONE NO_2 $PM_{2.5}$ PM_{10} CO	1-hr/Continuous 1-hr/Continuous 1-hr/Continuous 24/6 1-hr/Continuous	Rep. Conc. Rep. Conc. Rep. Conc. Rep. Conc. Rep. Conc.

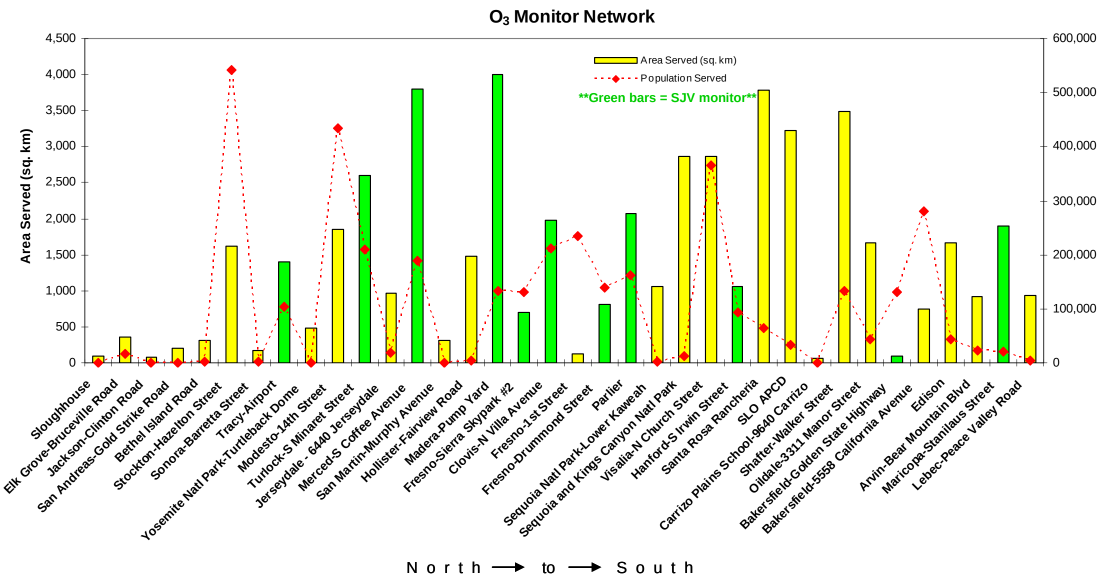
[a] Bakersfield–Golden State Highway is in planning stages of getting a trace level CO monitor; the Clovis site has a trace level CO analyzer.
[b] X sampling frequency for April-September is every six days and increases to sampling every three days for the months of October-March.
[c] The SJVUAPCD will be adding a temporary ozone monitor at Corcoran-Patterson for the 2008 ozone season.
Canister 4/3/3 = 4 hour sample, collected 3 times per day, every 3 days.

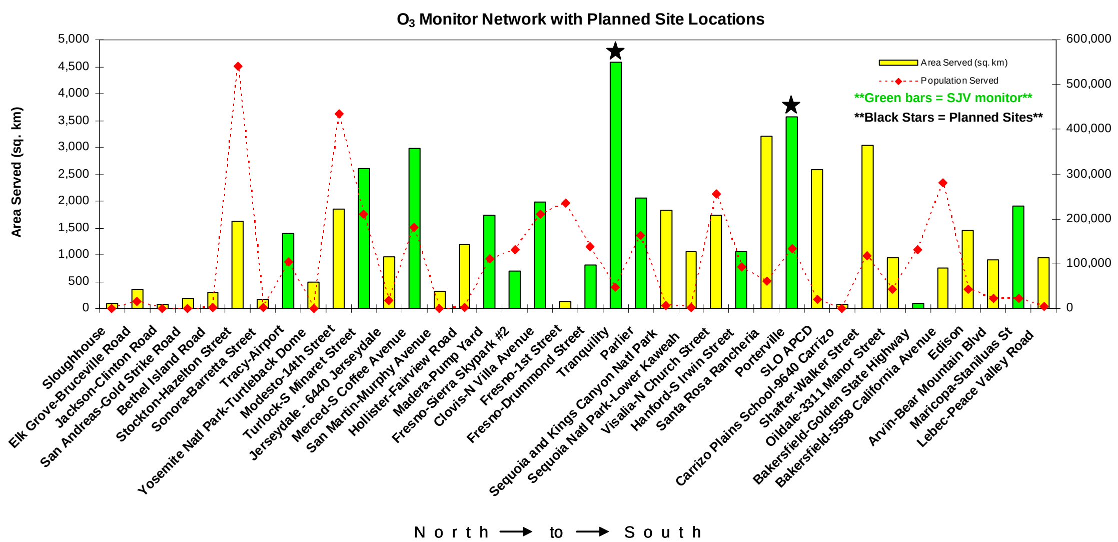
APPENDIX B

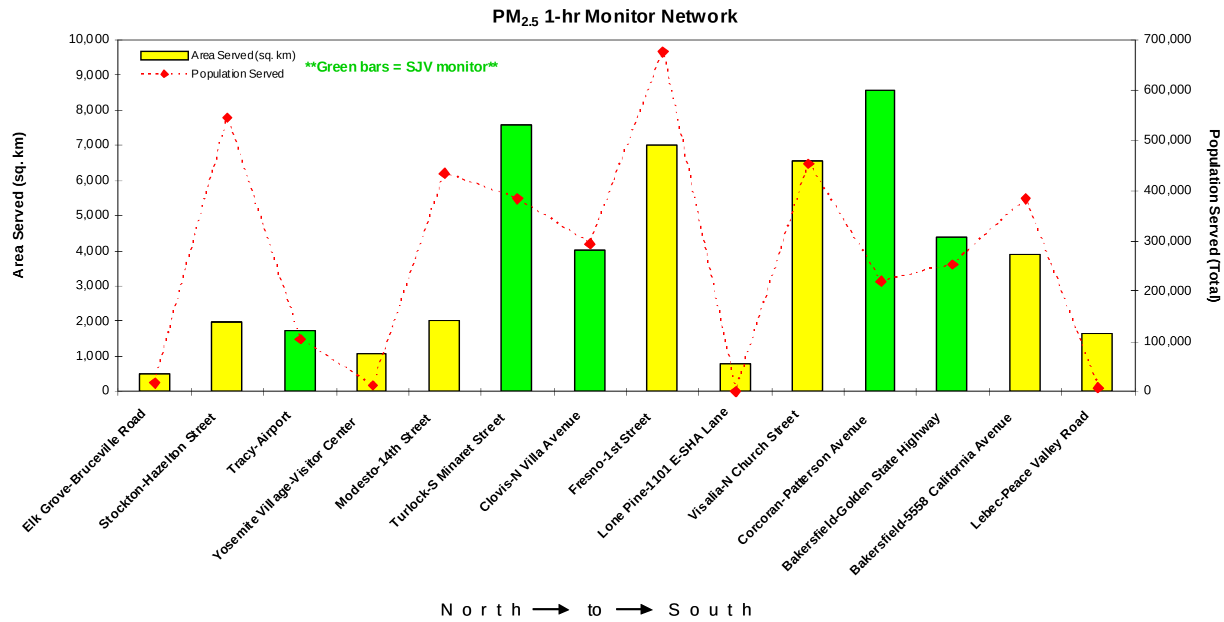
BOTTOM-UP ANALYSES

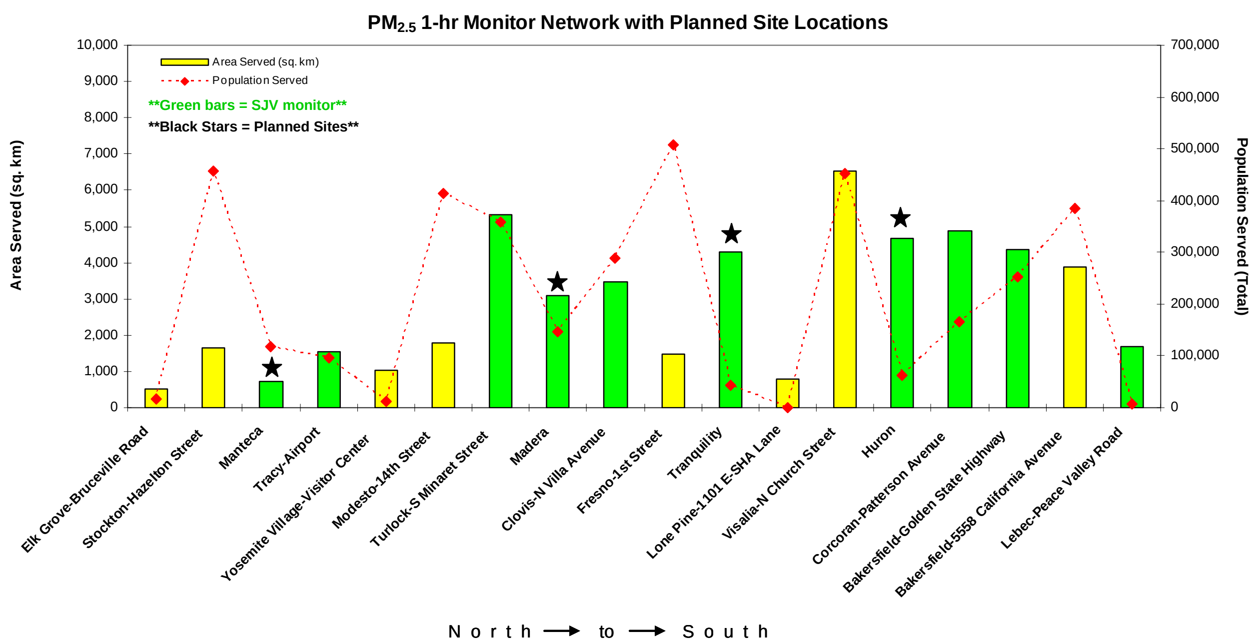
Appendix B contains graphs and maps for the bottom-up analyses described in Section 2. The appendix begins with area- and population-served graphs for each pollutant network, followed by population-change graphs and emissions-served graphs. The graphs depict current networks and planned/current networks wherever possible. The map section begins with the population-served ranking maps for each network, followed by population-change ranking maps, census block-group level population change overlaid on the area-served boundaries, and finally, spatially resolved emissions overlaid on the area-served boundaries.

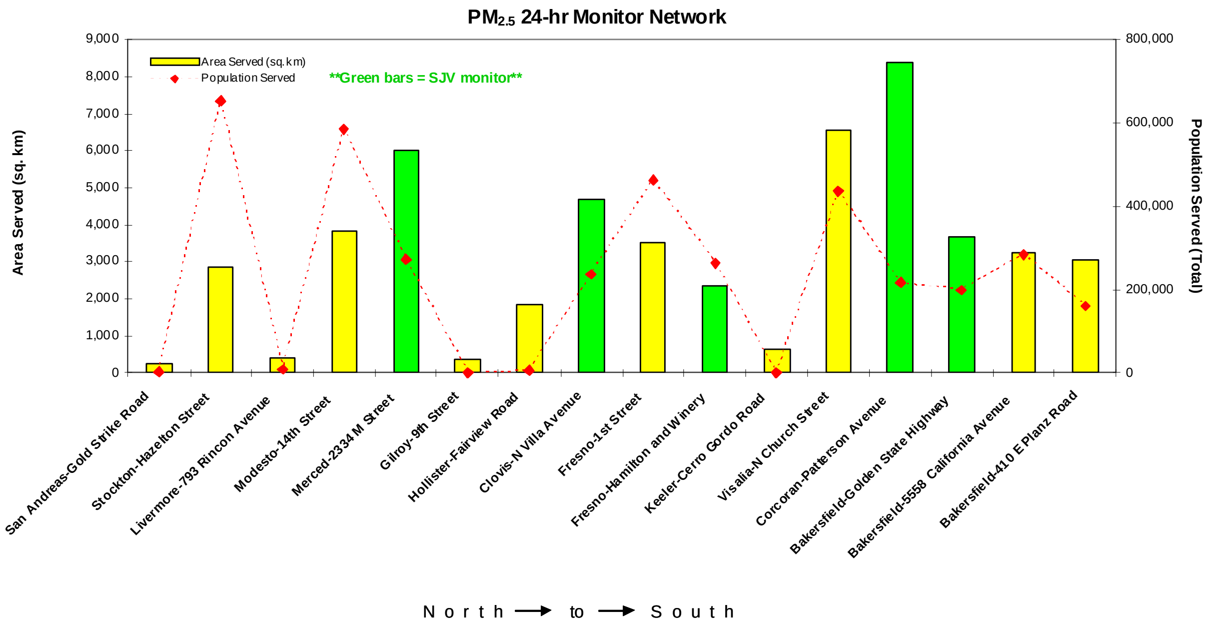
AREA AND POPULATION SERVED GRAPHS

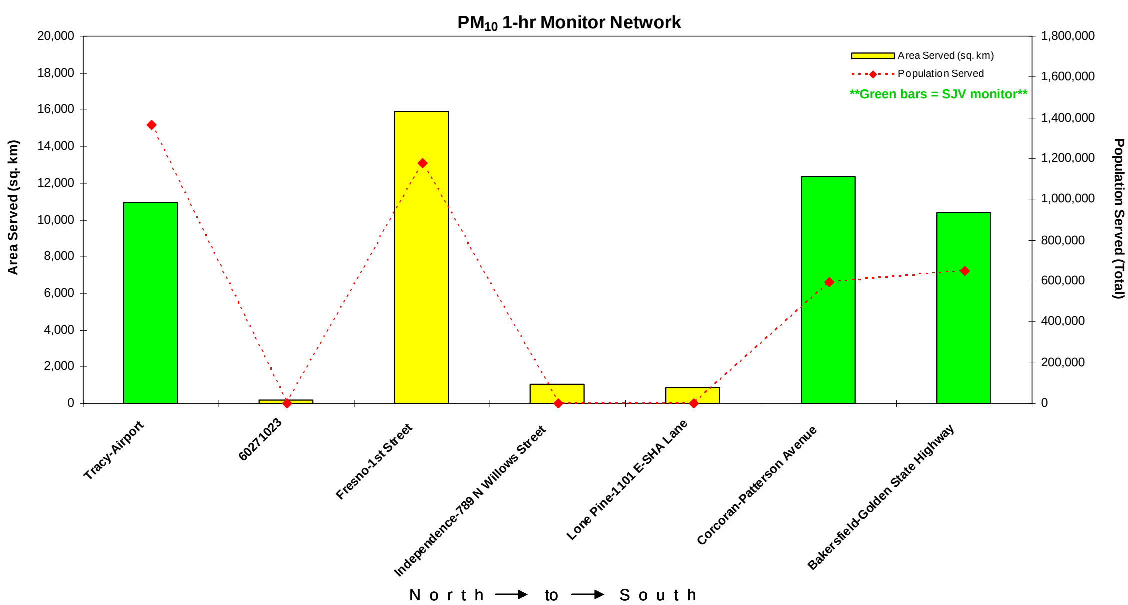


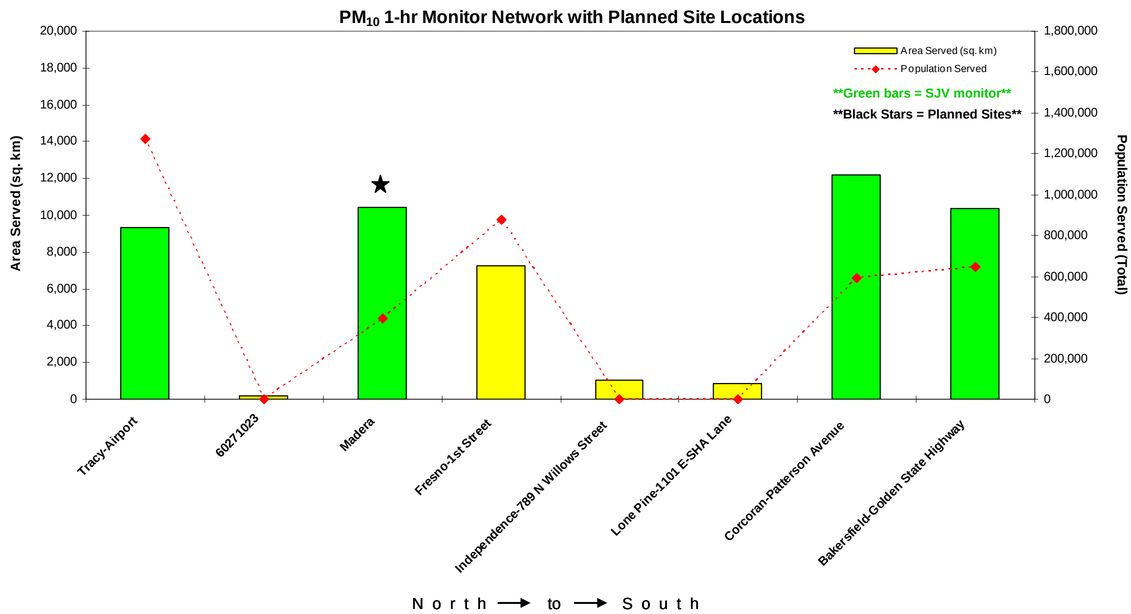


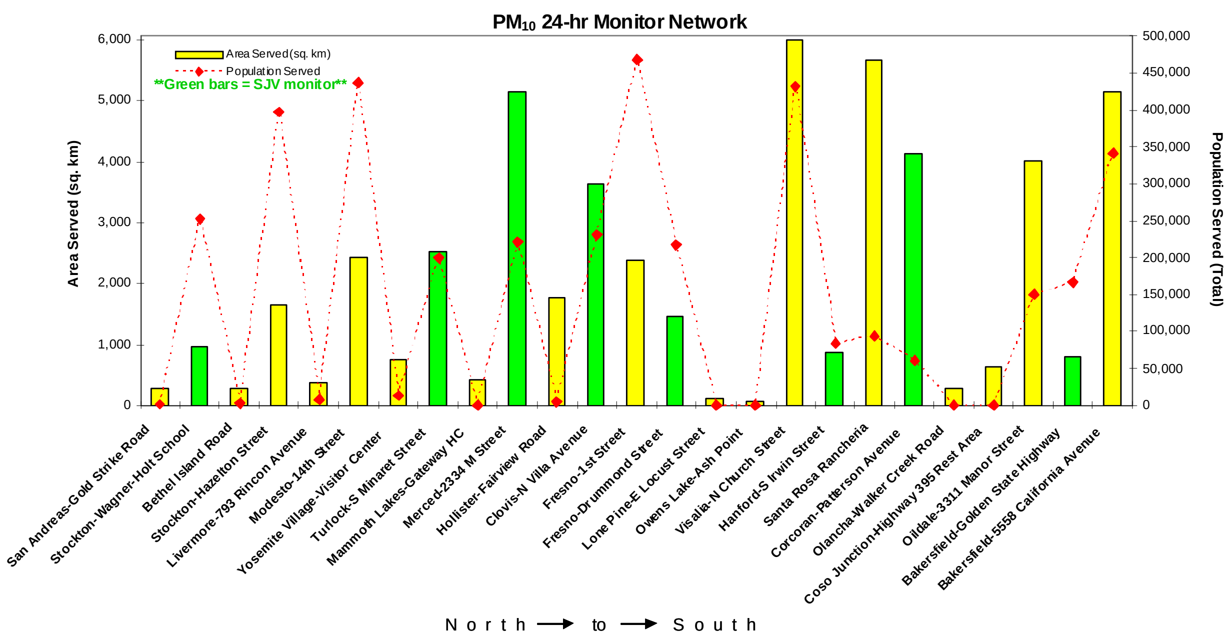

PM2.5 1-hr Monitor Network
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Area Served (sq. km)
Population Served (Total)
Elk Grove-Bruceville Road
Stockton-Hazelton Street
Tracy-Airport
Yosemite Village-Visitor Center
Modesto-14th Street
Turlock-S Minaret Street
Clovis-N Villa Avenue
Fresno-1st Street
Lone Pine-1101 E-SHA Lane
Visalia-N Church Street
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Lebec-Peace Valley Road
North to South

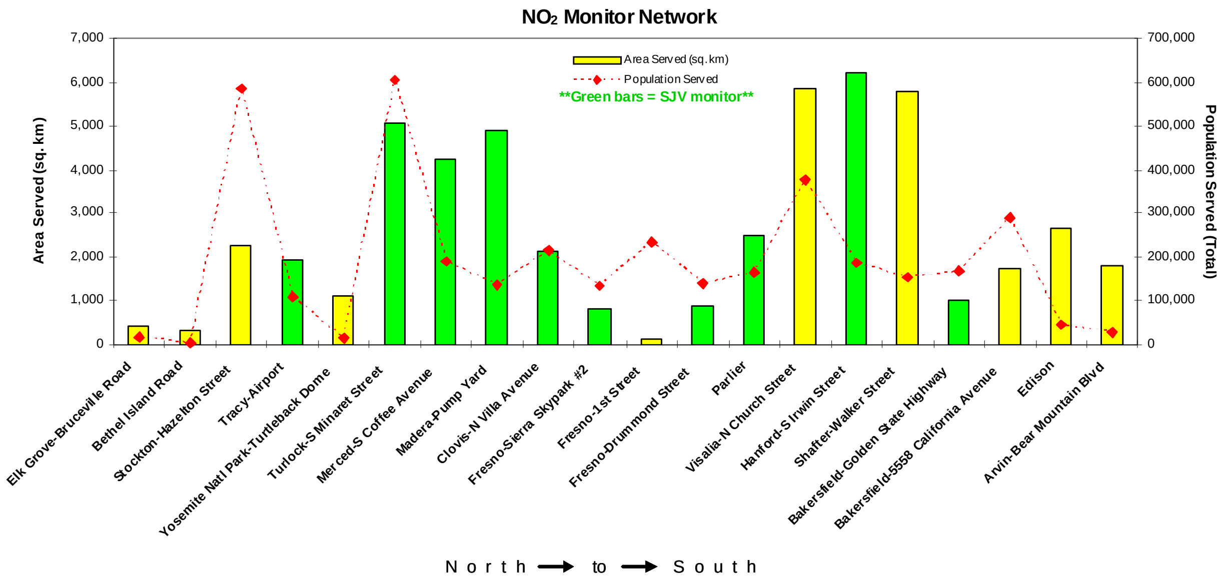

PM2.5 1-hr Monitor Network with Planned Site Locations
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Black Stars = Planned Sites
Area Served (sq. km)
Population Served (Total)
Elk Grove-Bruceville Road
Stockton-Hazelton Street
Manteca
Tracy-Airport
Yosemite Village-Visitor Center
Modesto-14th Street
Turlock-S Minaret Street
Madera
Clovis-N Villa Avenue
Fresno-1st Street
Tranquility
Lone Pine-1101 E-SHA Lane
Visalia-N Church Street
Huron
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Lebec-Peace Valley Road
North to South


PM2.5 24-hr Monitor Network
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Area Served (sq. km)
Population Served (Total)
San Andreas-Gold Strike Road
Stockton-Hazelton Street
Livermore-793 Rincon Avenue
Modesto-14th Street
Merced-2334 M Street
Gilroy-9th Street
Hollister-Fairview Road
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Hamilton and Winery
Keeler-Cerro Gordo Road
Visalia-N Church Street
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Bakersfield-410 E Planz Road
North → to → South

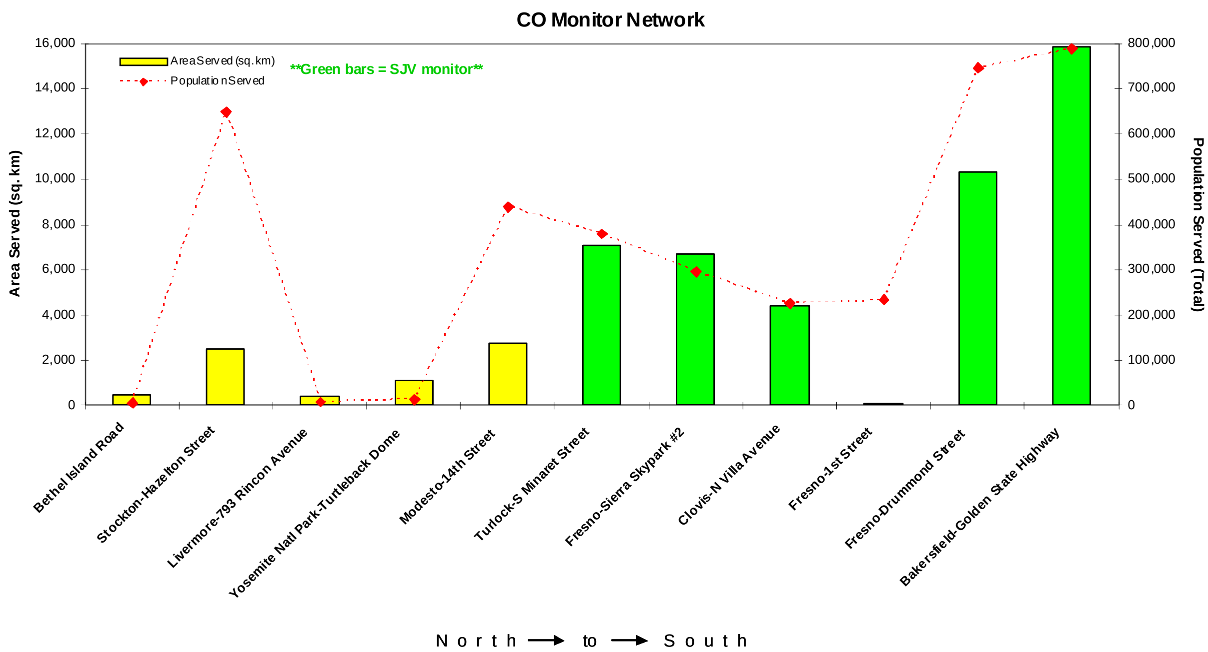

PM10 1-hr Monitor Network
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Area Served (sq. km)
Population Served (Total)
Tracy-Airport
60271023
Fresno-1st Street
Independence-789 N Willows Street
Lone Pine-1101 E-SHA Lane
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
North → to → South


PM10 1-hr Monitor Network with Planned Site Locations
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Black Stars = Planned Sites
Area Served (sq. km)
Population Served (Total)
Tracy-Airport
60271023
Madera
Fresno-1st Street
Independence-789 N Willows Street
Lone Pine-1101 E-SHA Lane
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
North to South

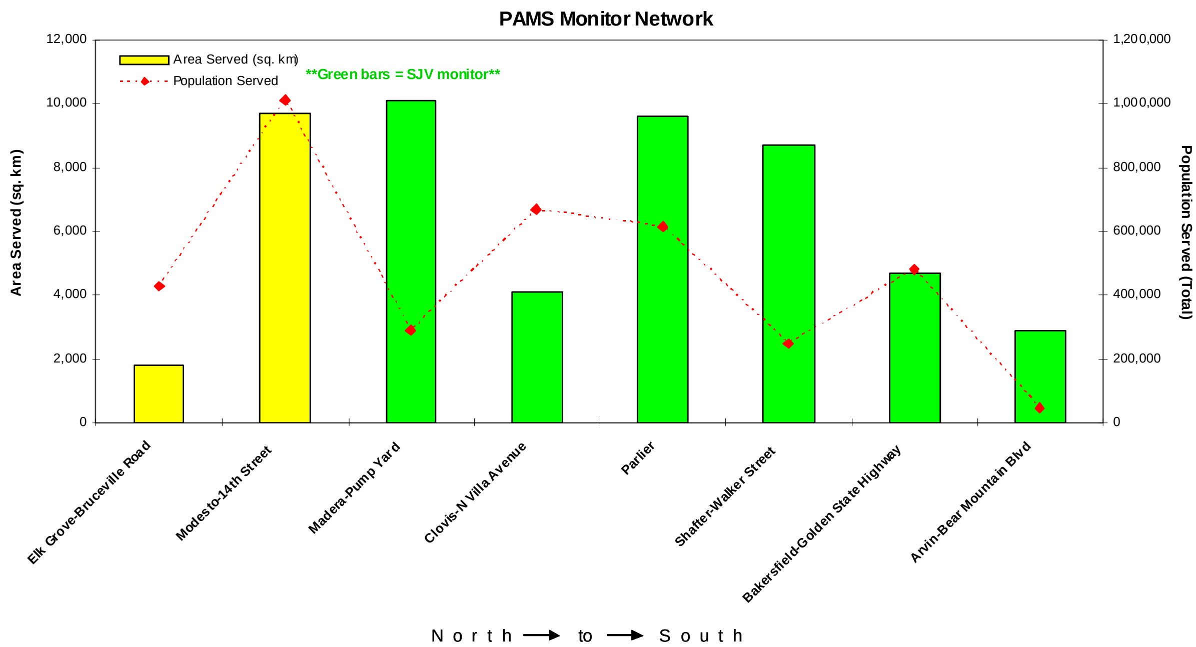

PM10 24-hr Monitor Network
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Area Served (sq. km)
Population Served (Total)
San Andreas-Gold Strike Road
Stockton-Wagner-Holt School
Bethel Island Road
Stockton-Hazelton Street
Livermore-793 Rincon Avenue
Modesto-14th Street
Yosemite Village-Visitor Center
Turlock-S Minaret Street
Mammoth Lakes-Gateway HC
Merced-2334 M Street
Hollister-Fairview Road
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Drummond Street
Lone Pine-E Locust Street
Owens Lake-Ash Point
Visalia-N Church Street
Hanford-S Irwin Street
Santa Rosa Rancheria
Corcoran-Patterson Avenue
Olancha-Walker Creek Road
Coso Junction-Highway 395 Rest Area
Oildale-3311 Manor Street
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
North to South



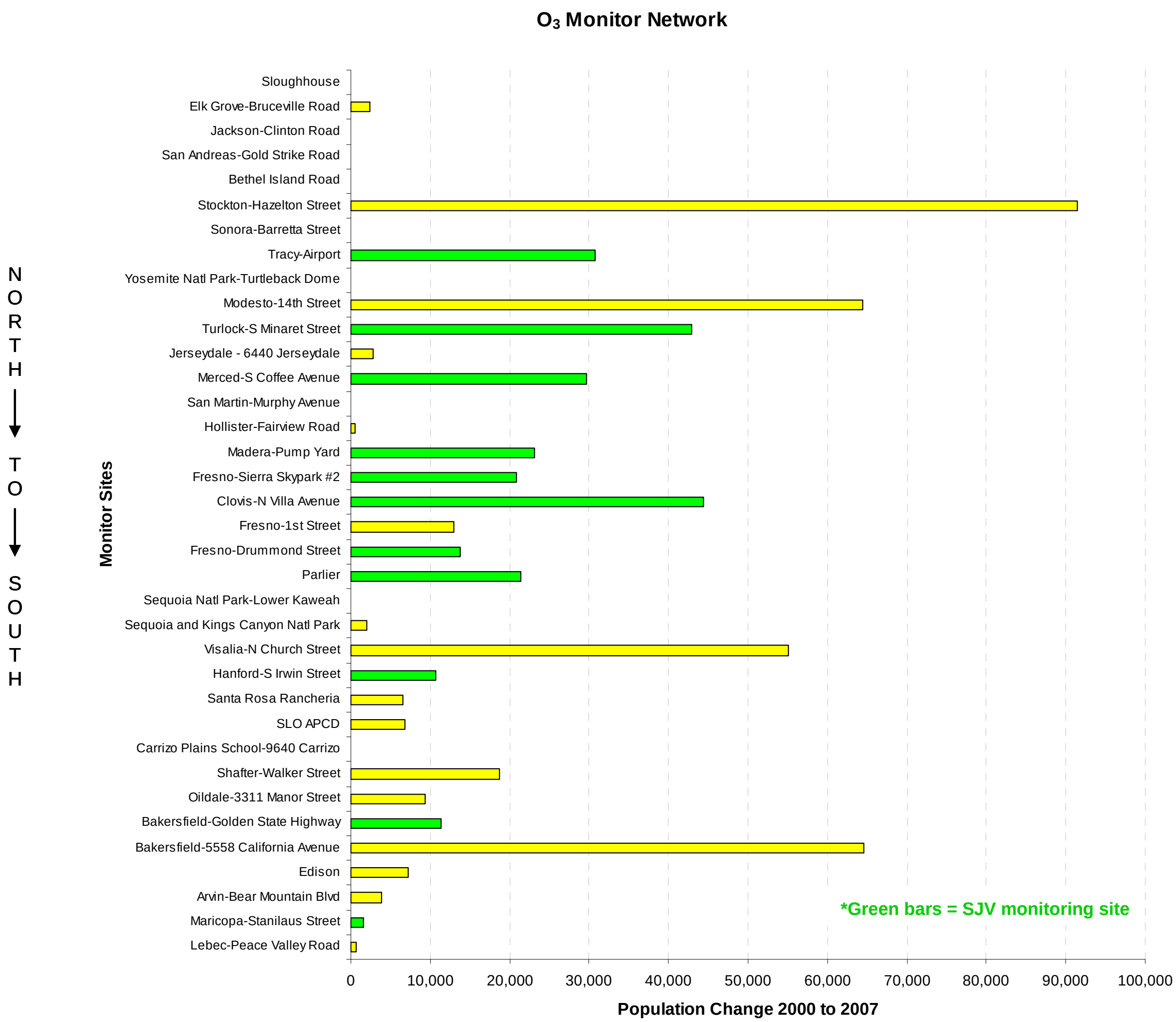
NO2 Monitor Network
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Area Served (sq. km)
Population Served (Total)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Elk Grove-Bruceville Road
Bethel Island Road
Stockton-Hazelton Street
Tracy-Airport
Yosemite Natl Park-Turtleback Dome
Turlock-S Minaret Street
Merced-S Coffee Avenue
Madera-Pump Yard
Clovis-N Villa Avenue
Fresno-Sierra Skypark #2
Fresno-1st Street
Fresno-Drummond Street
Parlier
Visalia-N Church Street
Hanford-S Irwin Street
Shafter-Walker Street
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Edison
Arvin-Bear Mountain Blvd
North to South



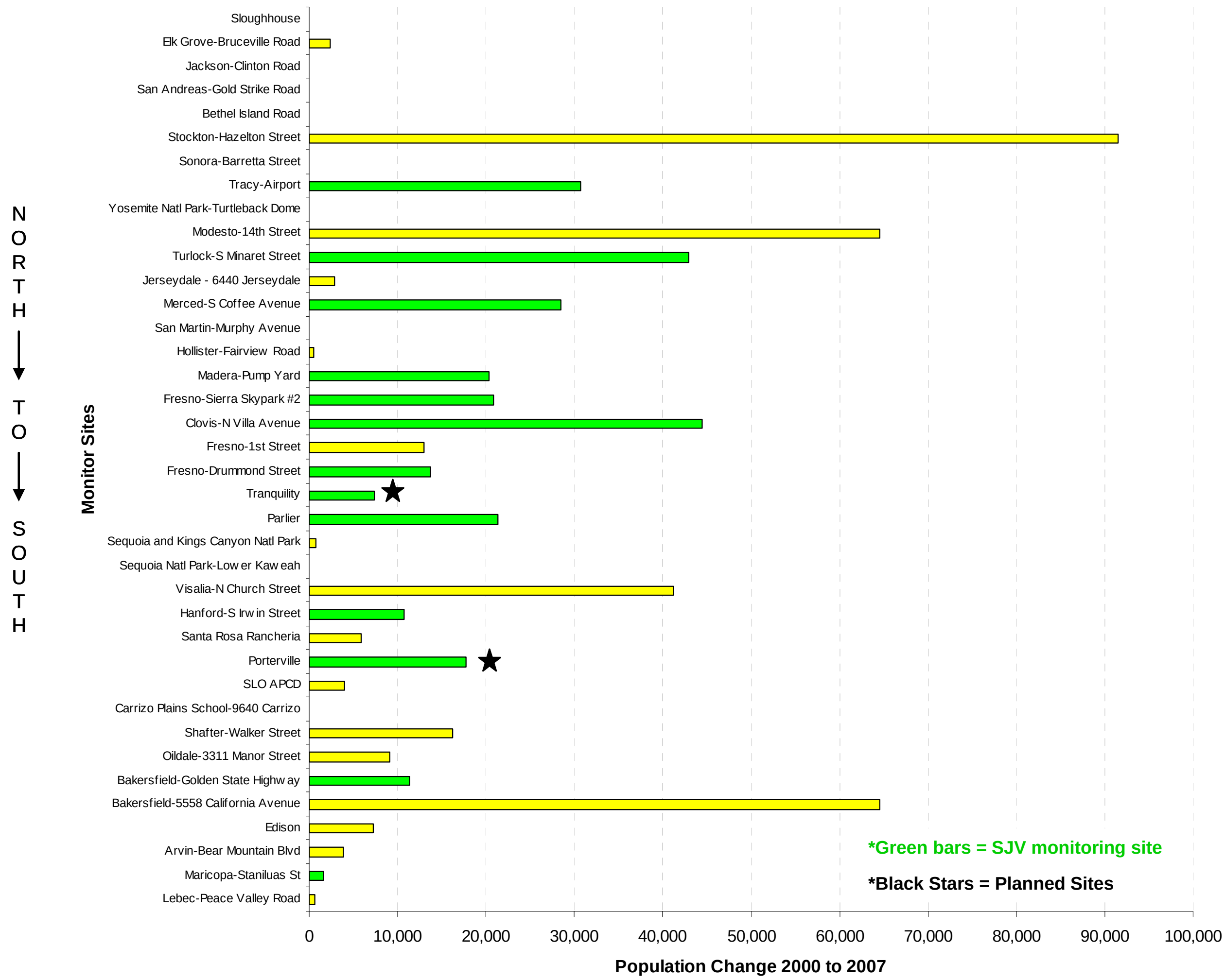
CO Monitor Network
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Area Served (sq. km)
Population Served (Total)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Bethel Island Road
Stockton-Hazelton Street
Livermore-793 Rincon Avenue
Yosemite Natl Park-Turtleback Dome
Modesto-14th Street
Turlock-S Minaret Street
Fresno-Sierra Skypark #2
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Drummond Street
Bakersfield-Golden State Highway
North to South


PAMS Monitor Network
Area Served (sq. km)
Population Served
Green bars = SJV monitor
Area Served (sq. km)
Population Served (Total)
12,000
10,000
8,000
6,000
4,000
2,000
0
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Elk Grove-Bruceville Road
Modesto-14th Street
Madera-Pump Yard
Clovis-N Villa Avenue
Parlier
Shafter-Walker Street
Bakersfield-Golden State Highway
Arvin-Bear Mountain Blvd
North to South

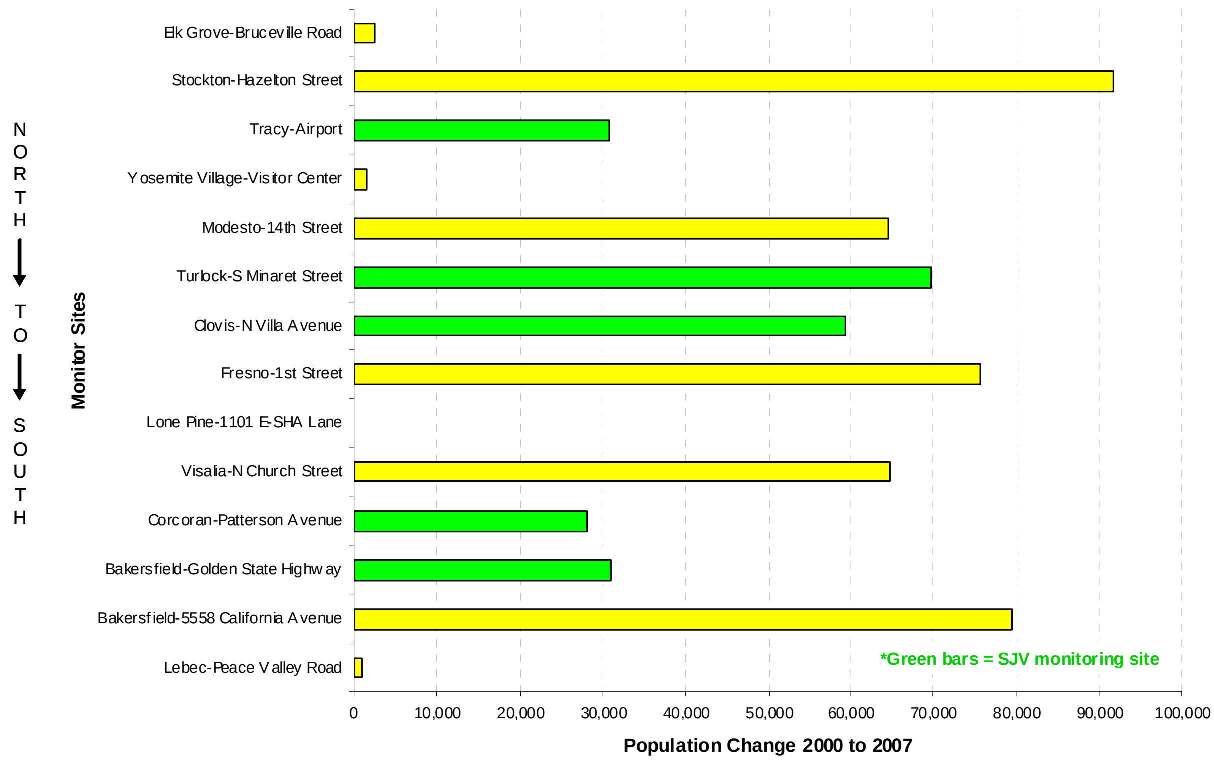
POPULATION CHANGE CHARTS



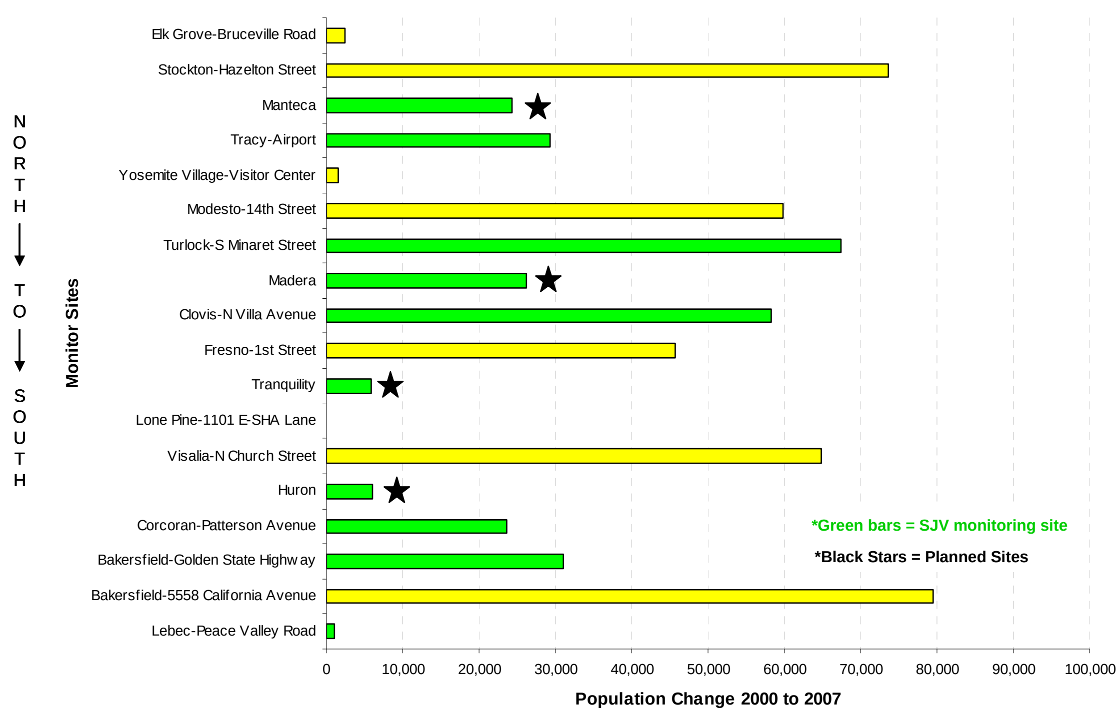
O_3 Monitor Network with Planned Site Locations

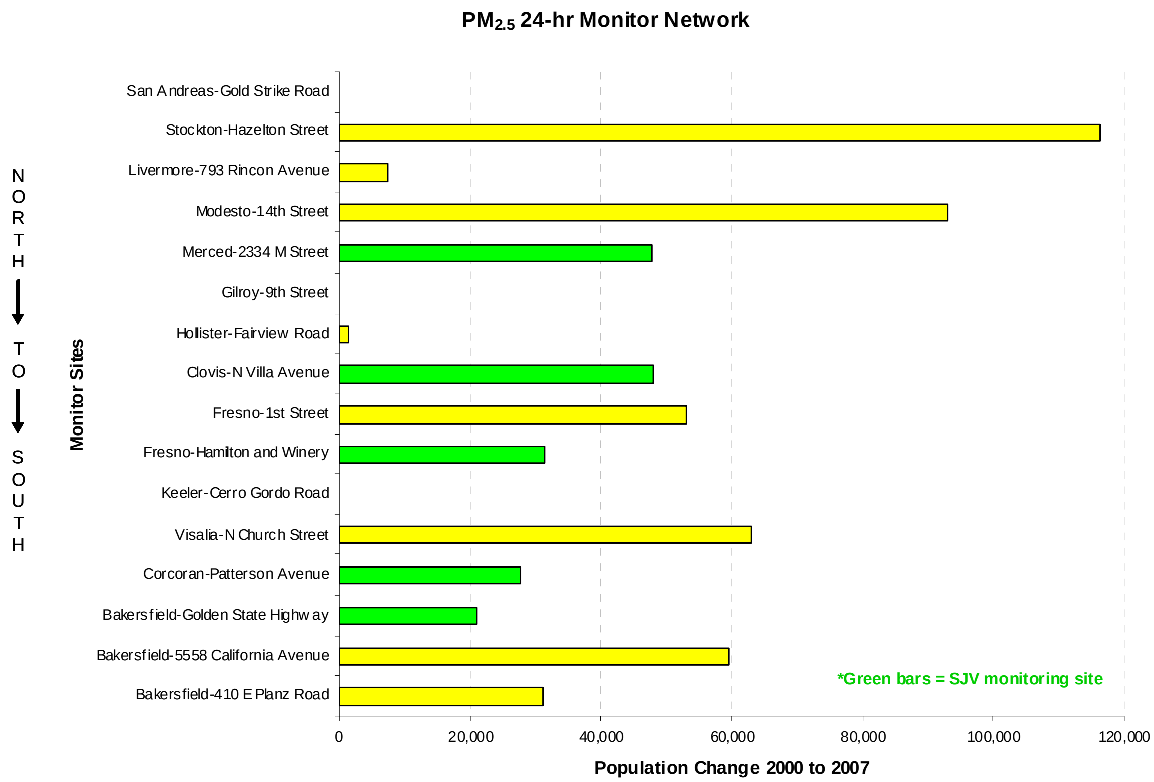


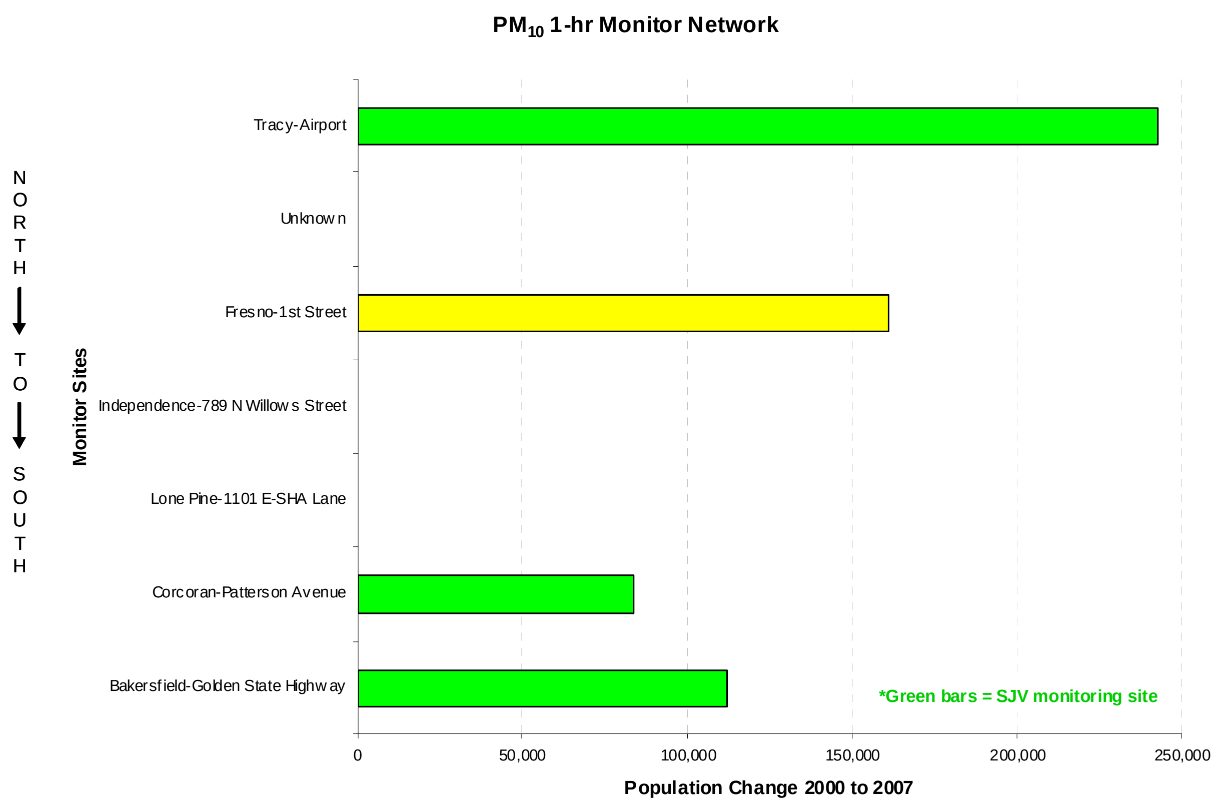
$PM_{2.5}$ 1-hr Monitor Network



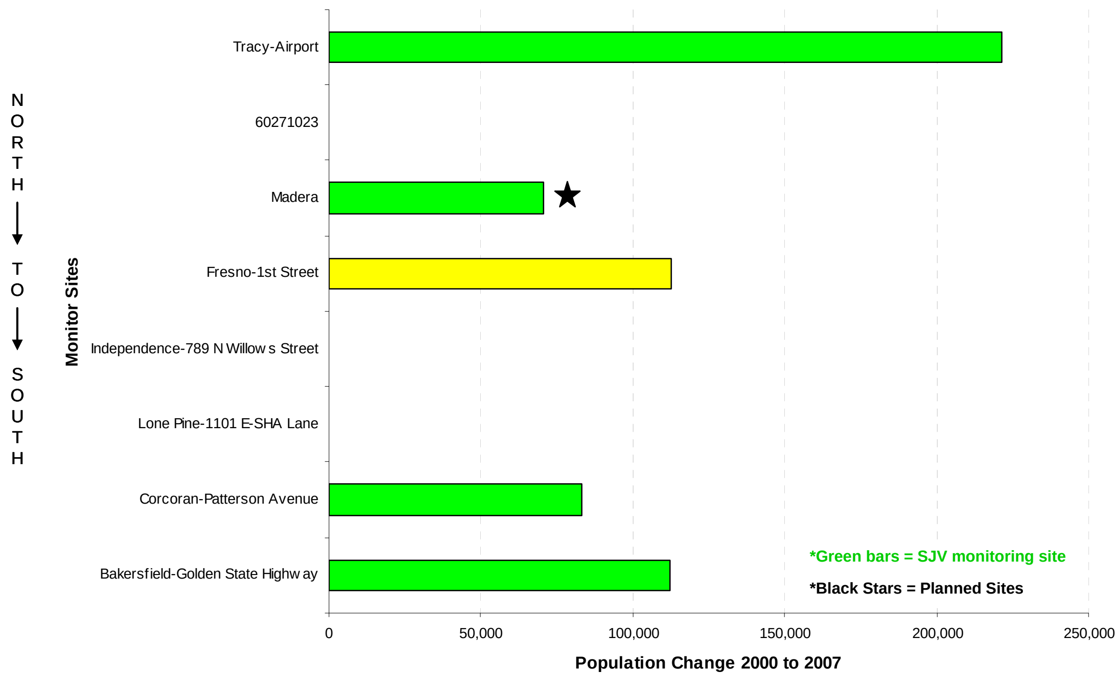
$PM_{2.5}$ 1-hr Monitor Network with Planned Site Locations

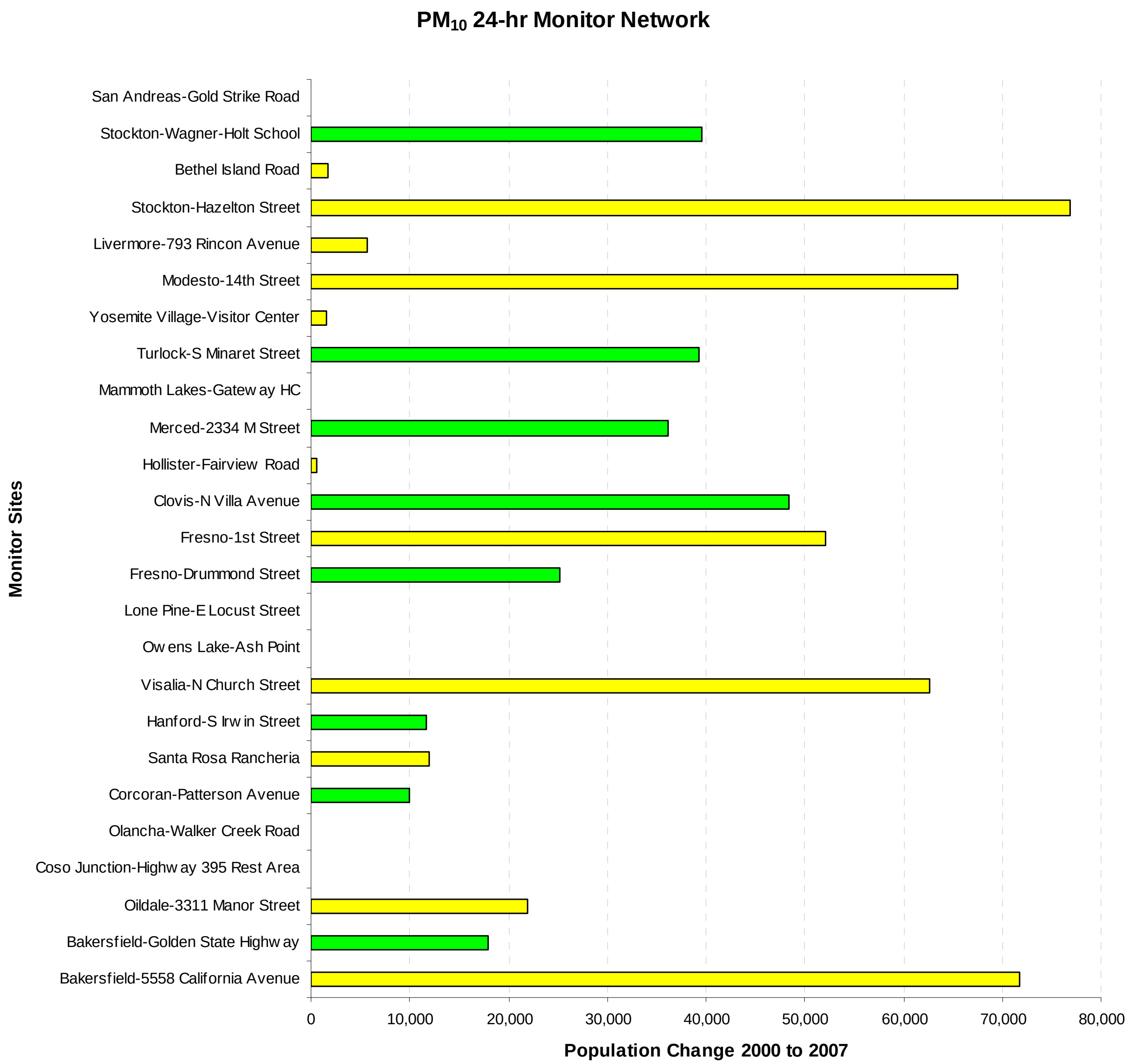


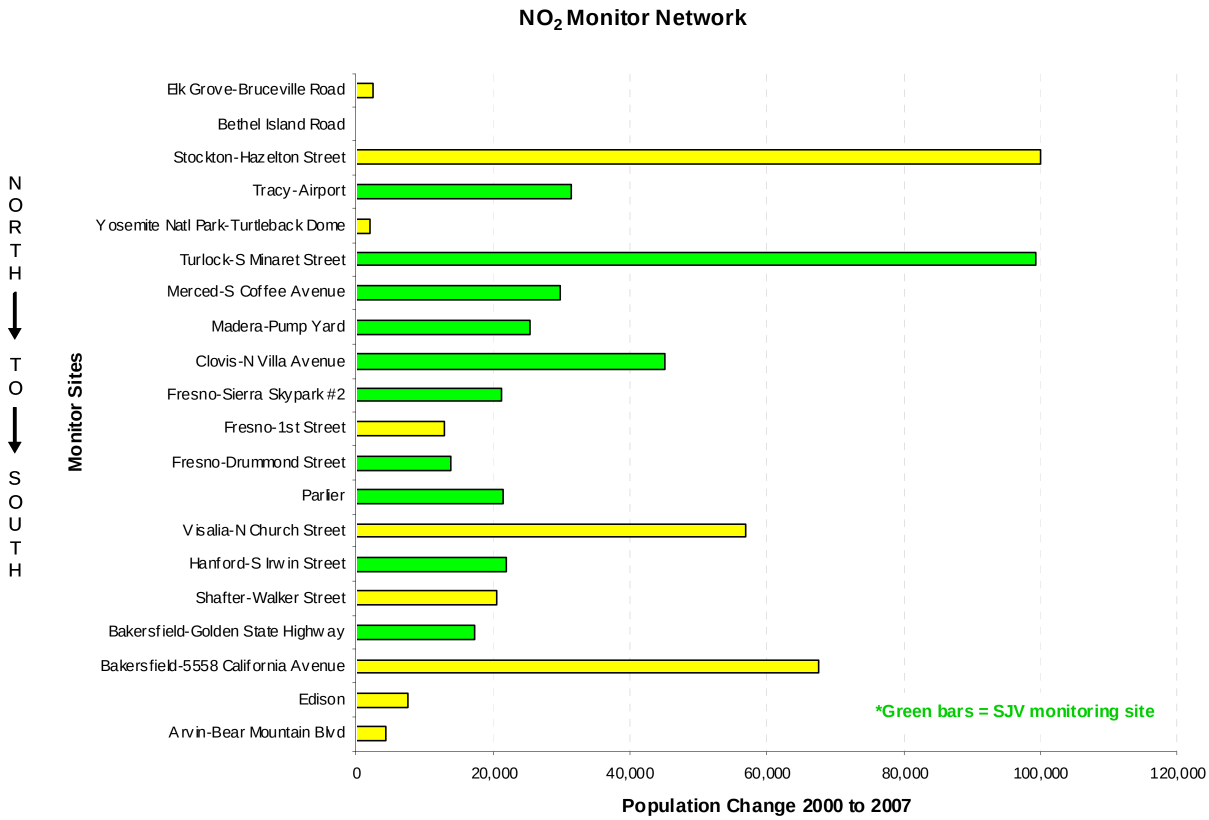

PM2.5 24-hr Monitor Network
N O R T H
T O
S O U T H
Monitor Sites
San Andreas-Gold Strike Road
Stockton-Hazelton Street
Livermore-793 Rincon Avenue
Modesto-14th Street
Merced-2334 M Street
Gilroy-9th Street
Hollister-Fairview Road
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Hamilton and Winery
Keeler-Cerro Gordo Road
Visalia-N Church Street
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Bakersfield-410 E Planz Road
*Green bars = SJV monitoring site
0
20,000
40,000
60,000
80,000
100,000
120,000
Population Change 2000 to 2007

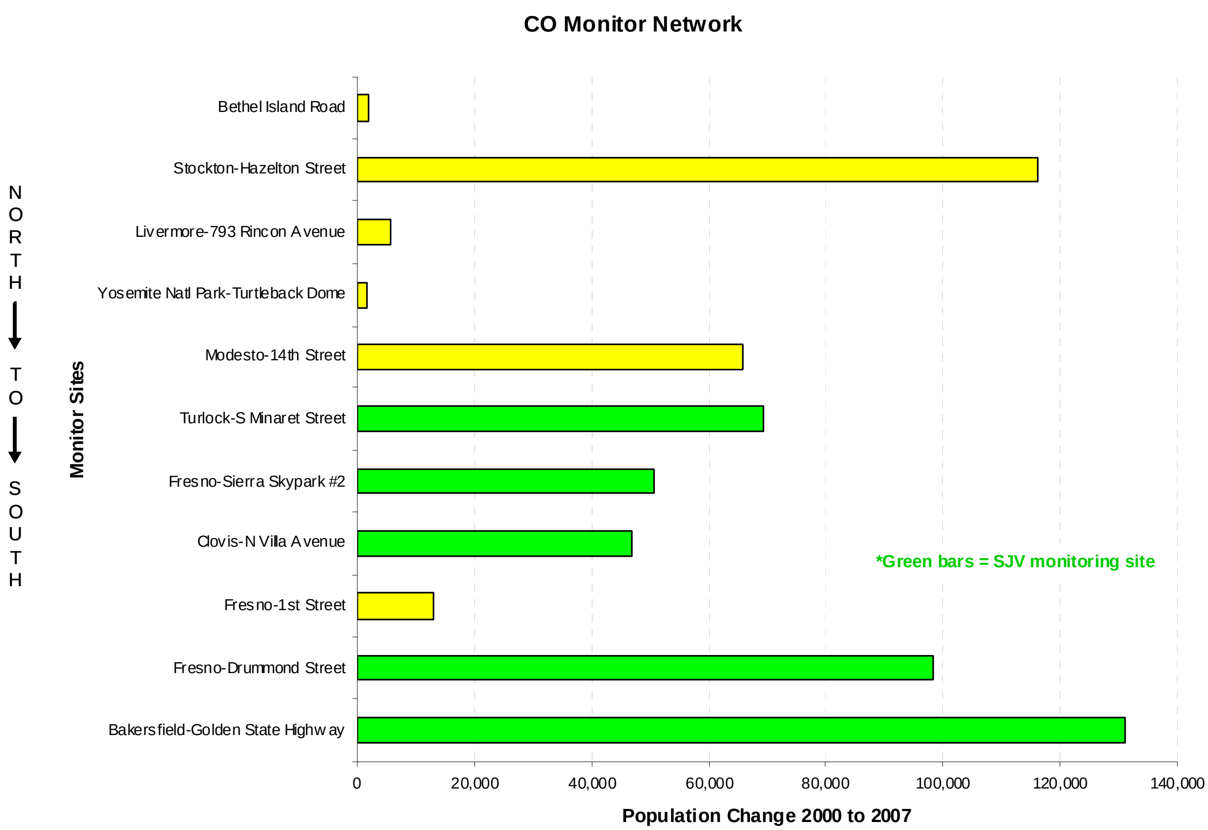

PM10 1-hr Monitor Network
N O R T H
T O
S O U T H
Monitor Sites
Tracy-Airport
Unknown
Fresno-1st Street
Independence-789 N Willows Street
Lone Pine-1101 E-SHA Lane
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
*Green bars = SJV monitoring site
0
50,000
100,000
150,000
200,000
250,000
Population Change 2000 to 2007

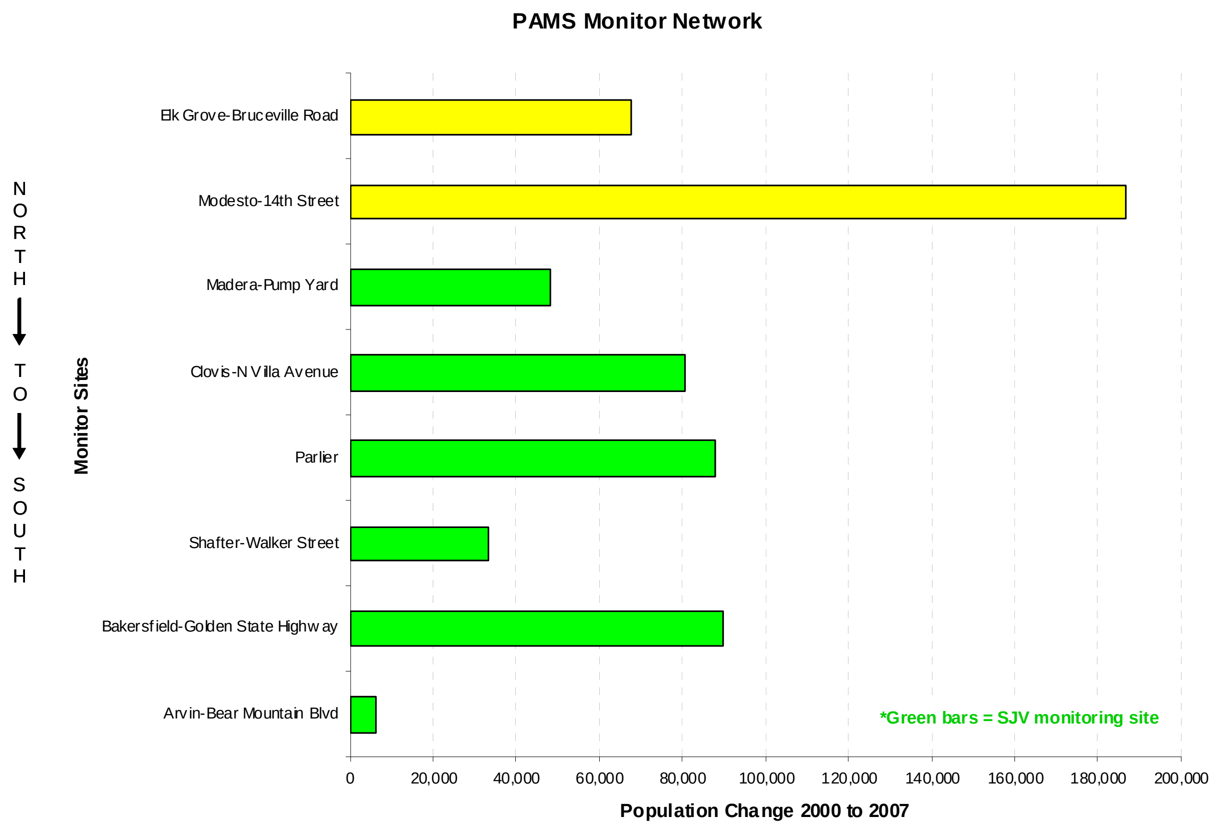
PM_{10} 1-hr Monitor Network with Planned Site Locations



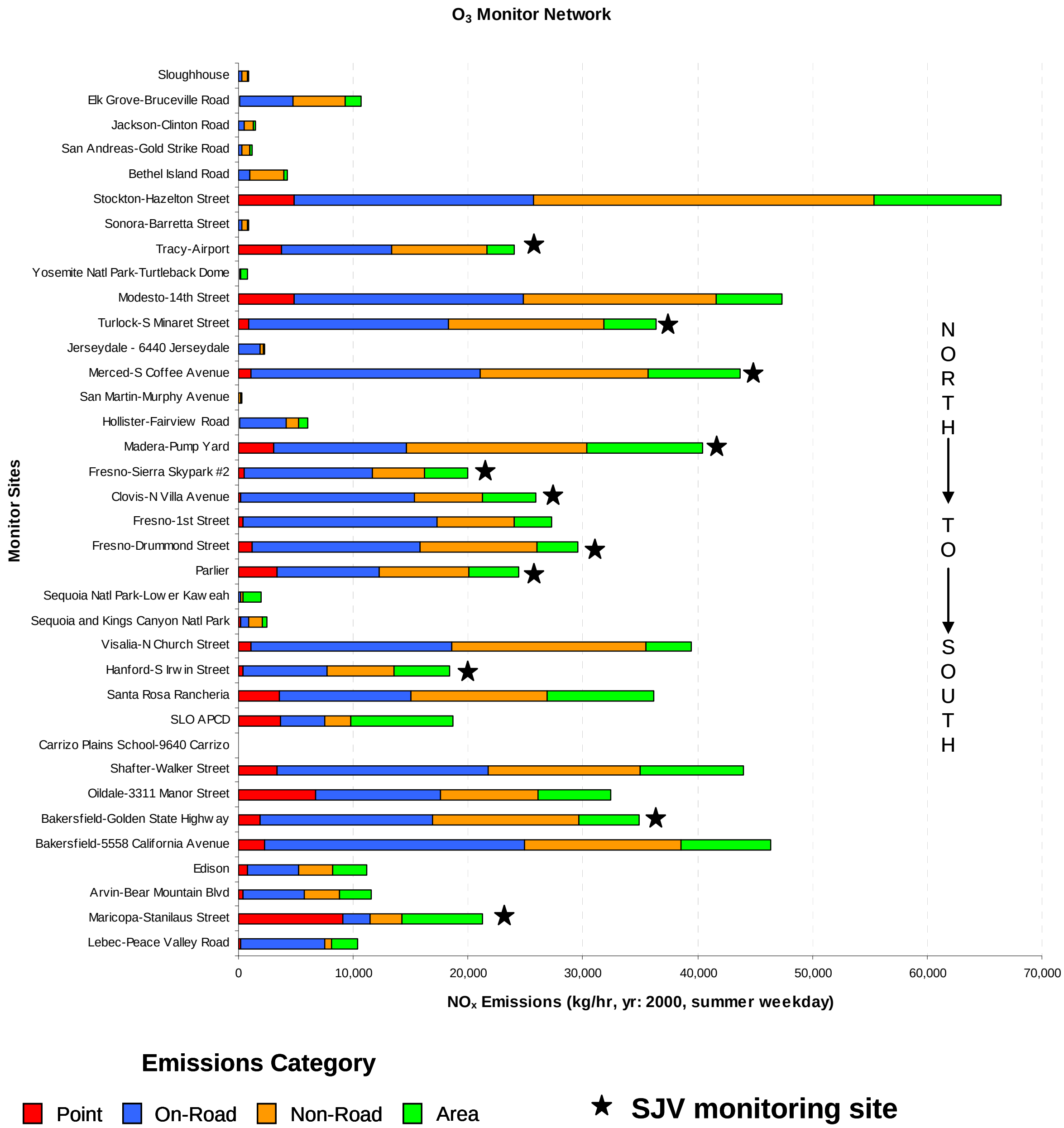

PM10 24-hr Monitor Network
Monitor Sites
San Andreas-Gold Strike Road
Stockton-Wagner-Holt School
Bethel Island Road
Stockton-Hazelton Street
Livermore-793 Rincon Avenue
Modesto-14th Street
Yosemite Village-Visitor Center
Turlock-S Minaret Street
Mammoth Lakes-Gateway HC
Merced-2334 M Street
Hollister-Fairview Road
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Drummond Street
Lone Pine-E Locust Street
Owens Lake-Ash Point
Visalia-N Church Street
Hanford-S Irwin Street
Santa Rosa Rancheria
Corcoran-Patterson Avenue
Olancha-Walker Creek Road
Coso Junction-Highway 395 Rest Area
Oildale-3311 Manor Street
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
Population Change 2000 to 2007

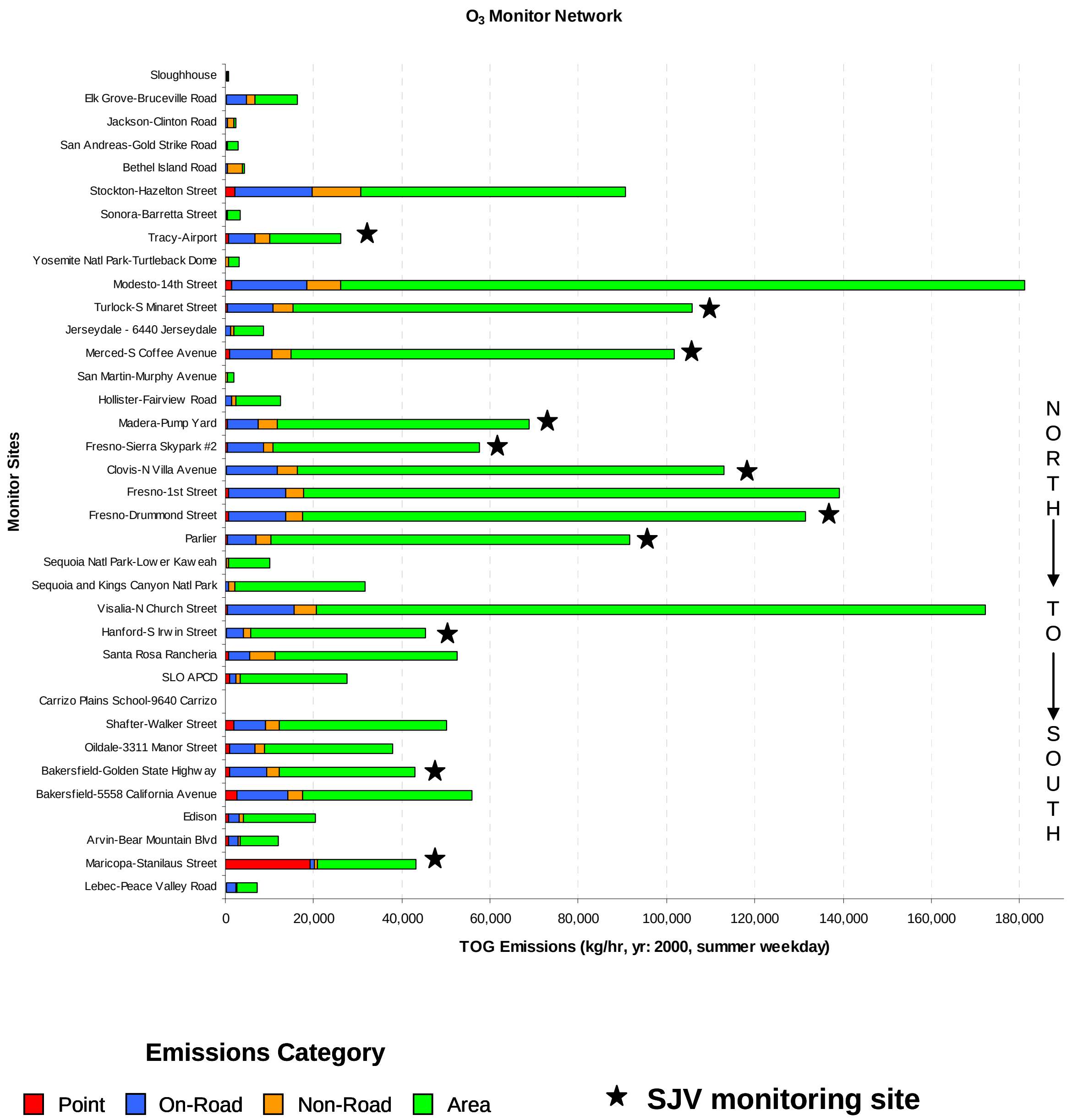

NO2 Monitor Network
NORTH TO SOUTH
Monitor Sites
Elk Grove-Bruceville Road
Bethel Island Road
Stockton-Hazelton Street
Tracy-Airport
Yosemite Natl Park-Turtleback Dome
Turlock-S Minaret Street
Merced-S Coffee Avenue
Madera-Pump Yard
Clovis-N Villa Avenue
Fresno-Sierra Skypark #2
Fresno-1st Street
Fresno-Drummond Street
Parlier
Visalia-N Church Street
Hanford-S Irwin Street
Shafter-Walker Street
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Edison
Arvin-Bear Mountain Blvd
*Green bars = SJV monitoring site
0
20,000
40,000
60,000
80,000
100,000
120,000
Population Change 2000 to 2007


CO Monitor Network
NORTH TO SOUTH
Monitor Sites
Bethel Island Road
Stockton-Hazelton Street
Livermore-793 Rincon Avenue
Yosemite Natl Park-Turtleback Dome
Modesto-14th Street
Turlock-S Minaret Street
Fresno-Sierra Skypark #2
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Drummond Street
Bakersfield-Golden State Highway
*Green bars = SJV monitoring site
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
Population Change 2000 to 2007

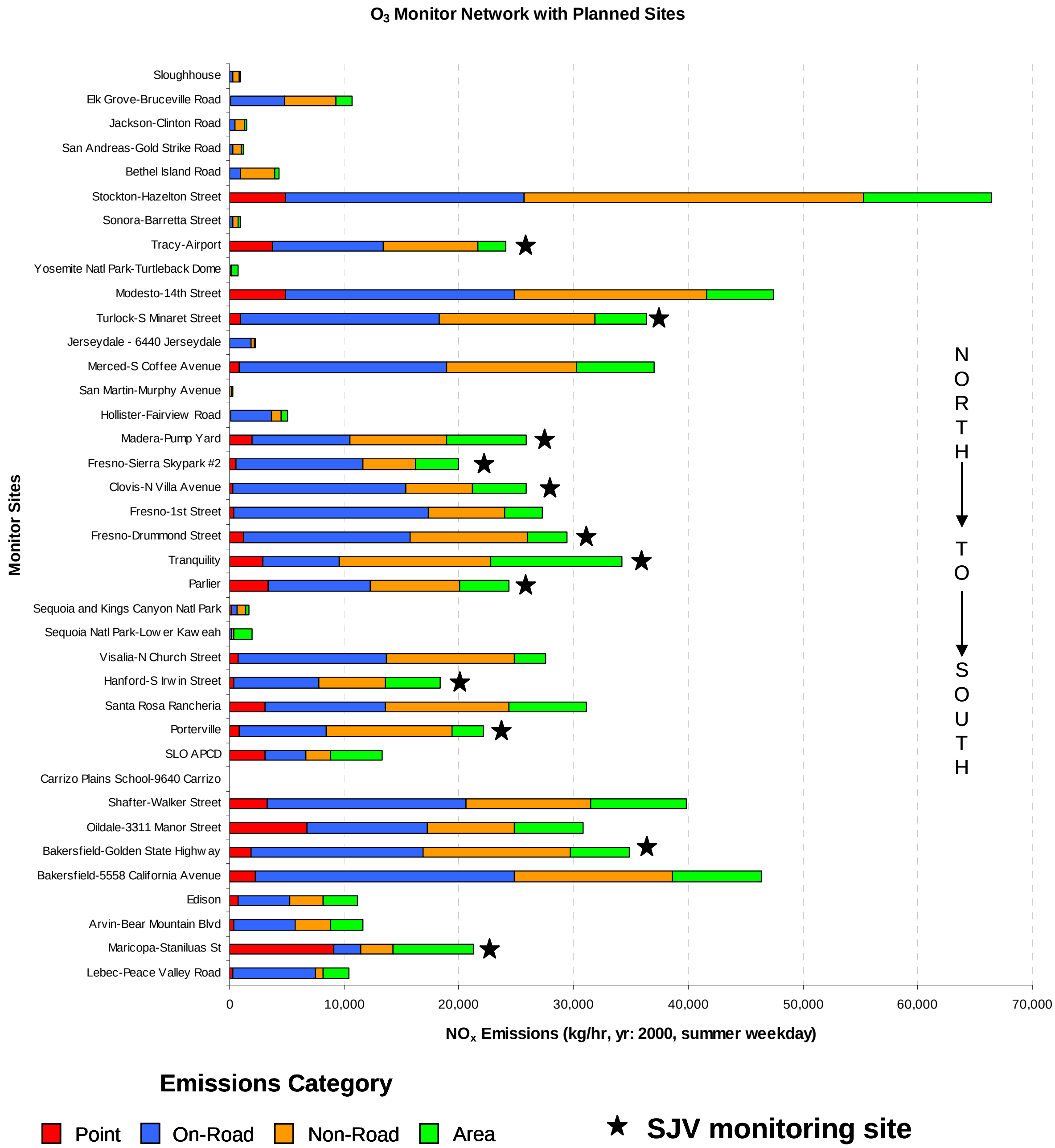

PAMS Monitor Network
N O R T H
T O
S O U T H
Monitor Sites
Elk Grove-Bruceville Road
Modesto-14th Street
Madera-Pump Yard
Clovis-N Villa Avenue
Parlier
Shafter-Walker Street
Bakersfield-Golden State Highway
Arvin-Bear Mountain Blvd
*Green bars = SJV monitoring site
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
Population Change 2000 to 2007

EMISSIONS SERVED CHARTS

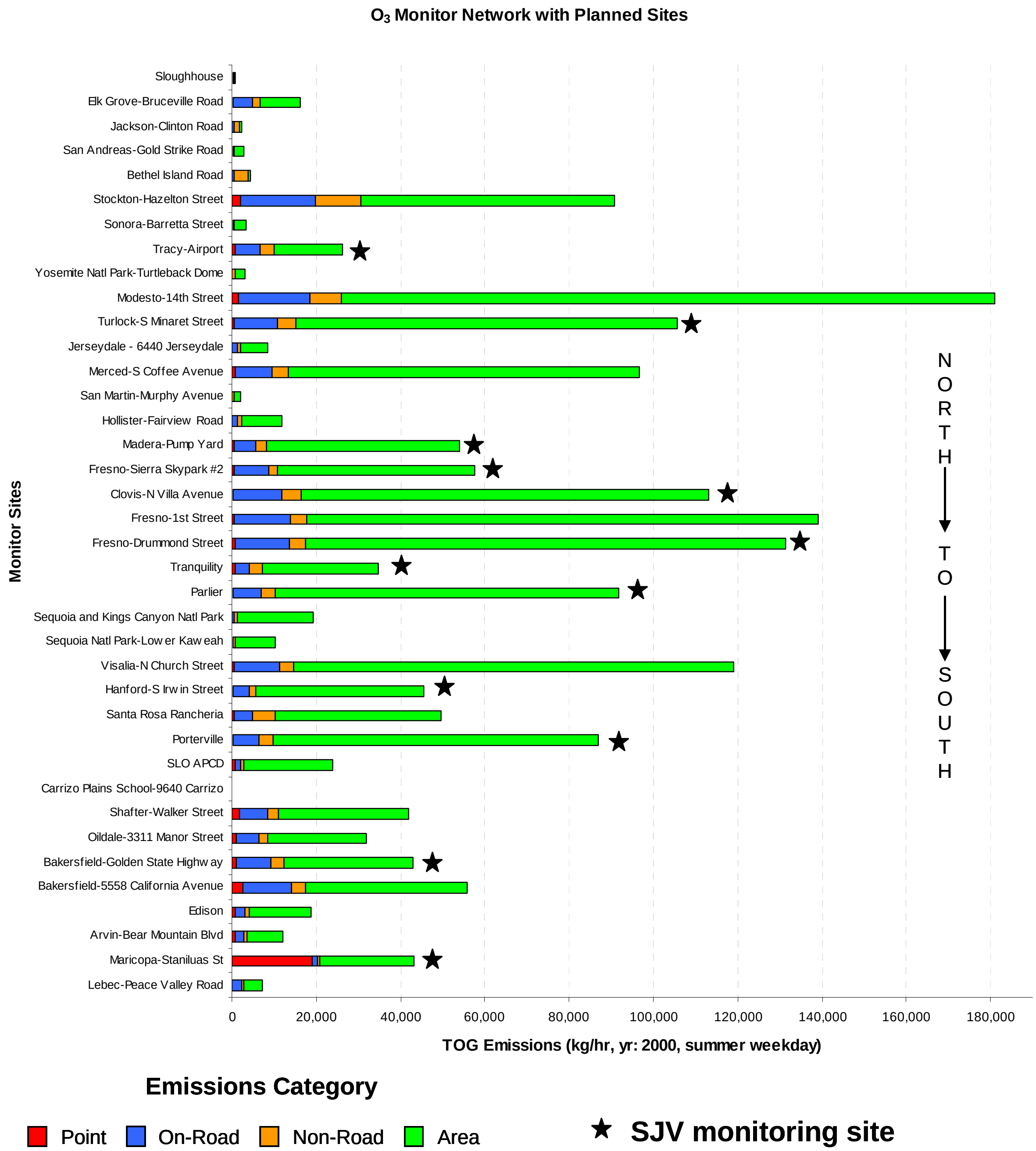




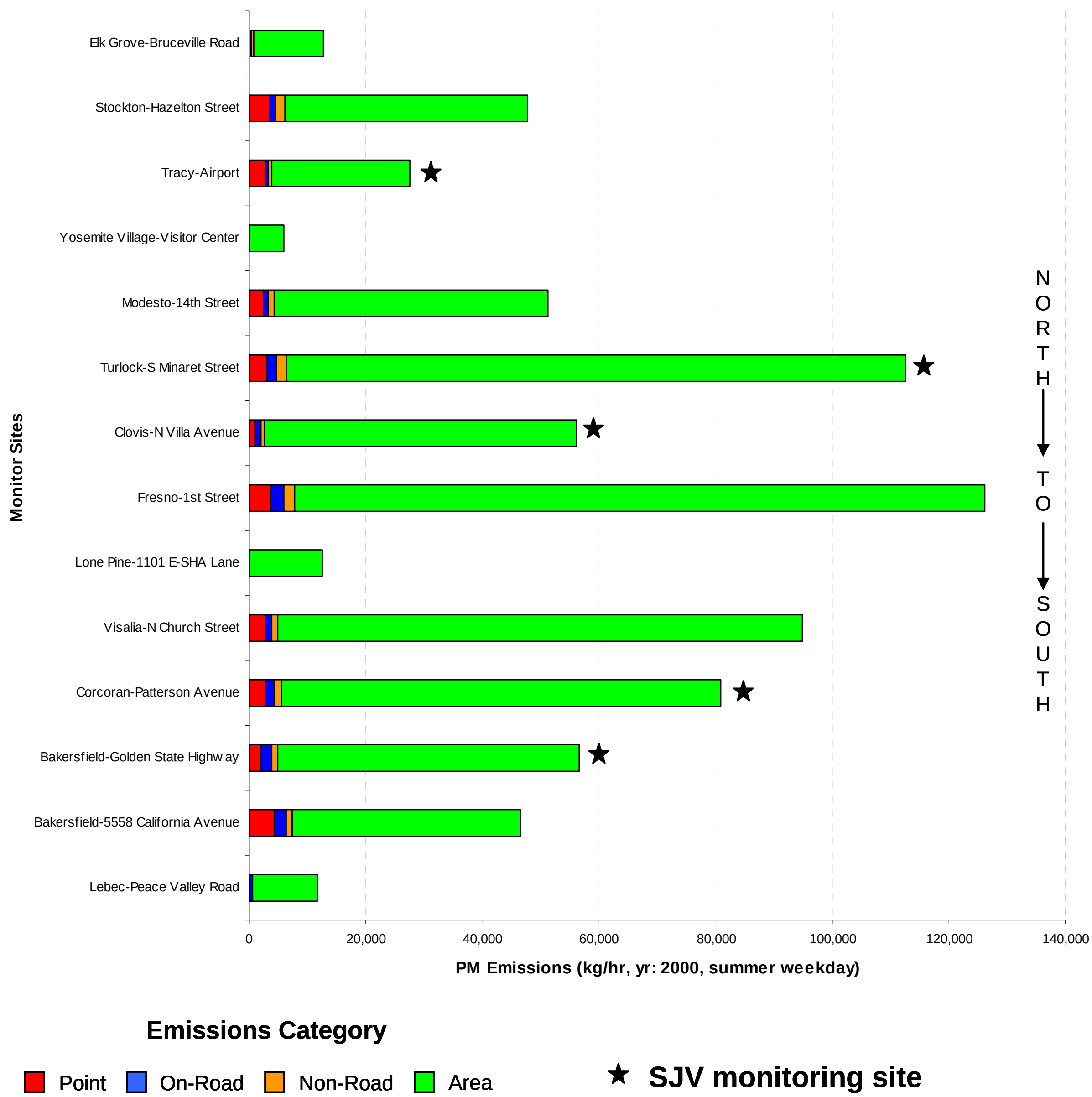
O3 Monitor Network
Monitor Sites
Sloughhouse
Elk Grove-Bruceville Road
Jackson-Clinton Road
San Andreas-Gold Strike Road
Bethel Island Road
Stockton-Hazelton Street
Sonora-Barretta Street
Tracy-Airport
Yosemite Natl Park-Turtleback Dome
Modesto-14th Street
Turlock-S Minaret Street
Jerseydale - 6440 Jerseydale
Merced-S Coffee Avenue
San Martin-Murphy Avenue
Hollister-Fairview Road
Madera-Pump Yard
Fresno-Sierra Skypark #2
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Drummond Street
Parlier
Sequoia Natl Park-Lower Kaweah
Sequoia and Kings Canyon Natl Park
Visalia-N Church Street
Hanford-S Irwin Street
Santa Rosa Rancheria
SLO APCD
Carrizo Plains School-9640 Carrizo
Shafter-Walker Street
Oildale-3311 Manor Street
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Edison
Arvin-Bear Mountain Blvd
Maricopa-Stanilaus Street
Lebec-Peace Valley Road
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
TOG Emissions (kg/hr, yr: 2000, summer weekday)
NORTH TO SOUTH
Emissions Category
Point
On-Road
Non-Road
Area
SJV monitoring site

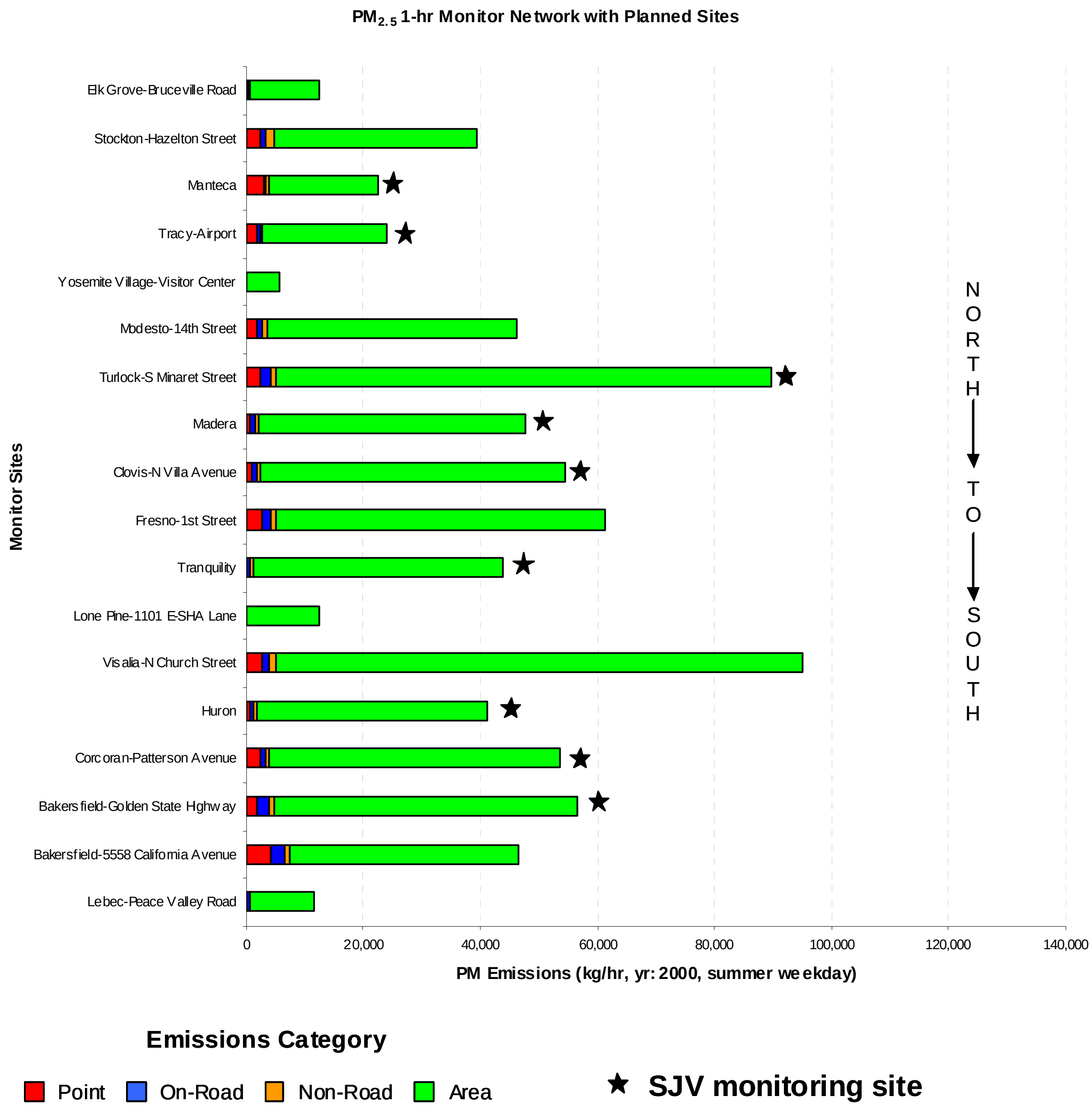


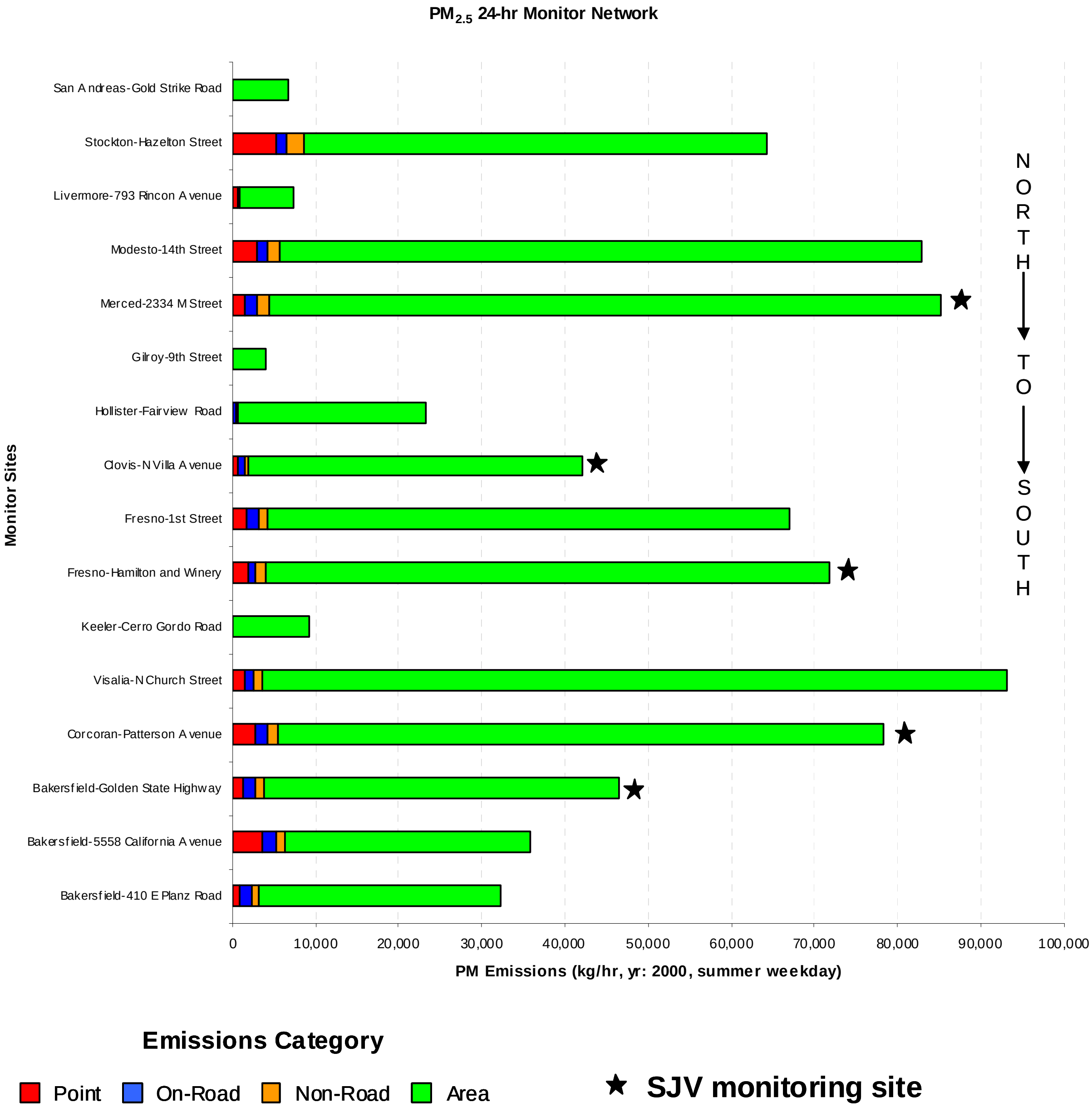
O3 Monitor Network with Planned Sites
Sloughhouse
Elk Grove-Bruceville Road
Jackson-Clinton Road
San Andreas-Gold Strike Road
Bethel Island Road
Stockton-Hazelton Street
Sonora-Barretta Street
Tracy-Airport
Yosemite Natl Park-Turtleback Dome
Modesto-14th Street
Turlock-S Minaret Street
Jerseydale - 6440 Jerseydale
Merced-S Coffee Avenue
San Martin-Murphy Avenue
Hollister-Fairview Road
Madera-Pump Yard
Fresno-Sierra Skypark #2
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Drummond Street
Tranquility
Parlier
Sequoia and Kings Canyon Natl Park
Sequoia Natl Park-Lower Kaweah
Visalia-N Church Street
Hanford-S Irwin Street
Santa Rosa Rancheria
Porterville
SLO APCD
Carrizo Plains School-9640 Carrizo
Shafter-Walker Street
Oildale-3311 Manor Street
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Edison
Arvin-Bear Mountain Blvd
Maricopa-Staniluas St
Lebec-Peace Valley Road
Monitor Sites
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
NOx Emissions (kg/hr, yr: 2000, summer weekday)
NORTH TO SOUTH
Emissions Category
Point
On-Road
Non-Road
Area
SJV monitoring site

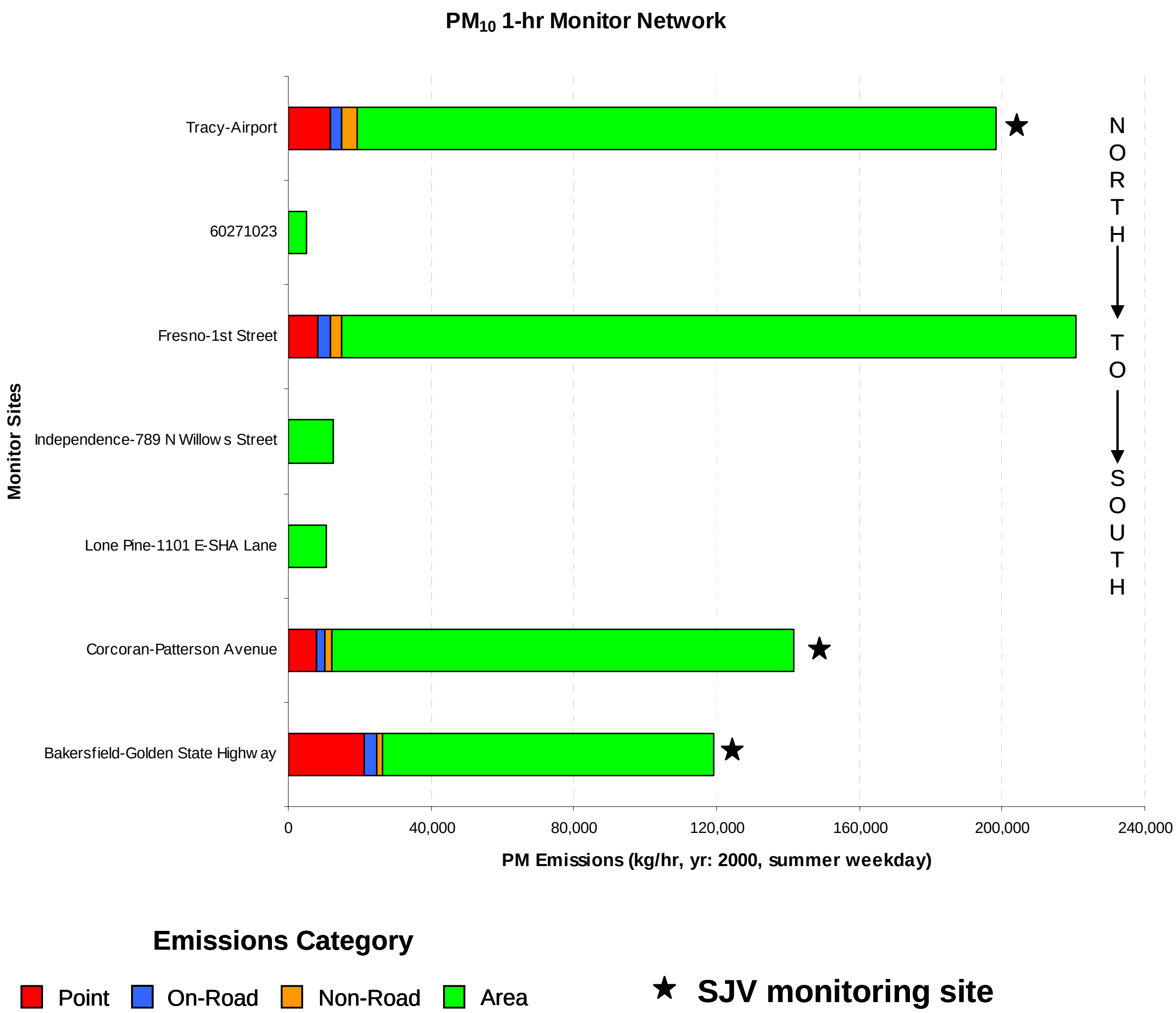

O3 Monitor Network with Planned Sites
Monitor Sites
Sloughhouse
Elk Grove-Bruceville Road
Jackson-Clinton Road
San Andreas-Gold Strike Road
Bethel Island Road
Stockton-Hazelton Street
Sonora-Barretta Street
Tracy-Airport
Yosemite Natl Park-Turtleback Dome
Modesto-14th Street
Turlock-S Minaret Street
Jerseydale - 6440 Jerseydale
Merced-S Coffee Avenue
San Martin-Murphy Avenue
Hollister-Fairview Road
Madera-Pump Yard
Fresno-Sierra Skypark #2
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Drummond Street
Tranquility
Parlier
Sequoia and Kings Canyon Natl Park
Sequoia Natl Park-Lower Kaweah
Visalia-N Church Street
Hanford-S Irwin Street
Santa Rosa Rancheria
Porterville
SLO APCD
Carrizo Plains School-9640 Carrizo
Shafter-Walker Street
Oildale-3311 Manor Street
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Edison
Arvin-Bear Mountain Blvd
Maricopa-Staniluas St
Lebec-Peace Valley Road
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
TOG Emissions (kg/hr, yr: 2000, summer weekday)
NORTH TO SOUTH
Emissions Category
Point
On-Road
Non-Road
Area
★ SJV monitoring site

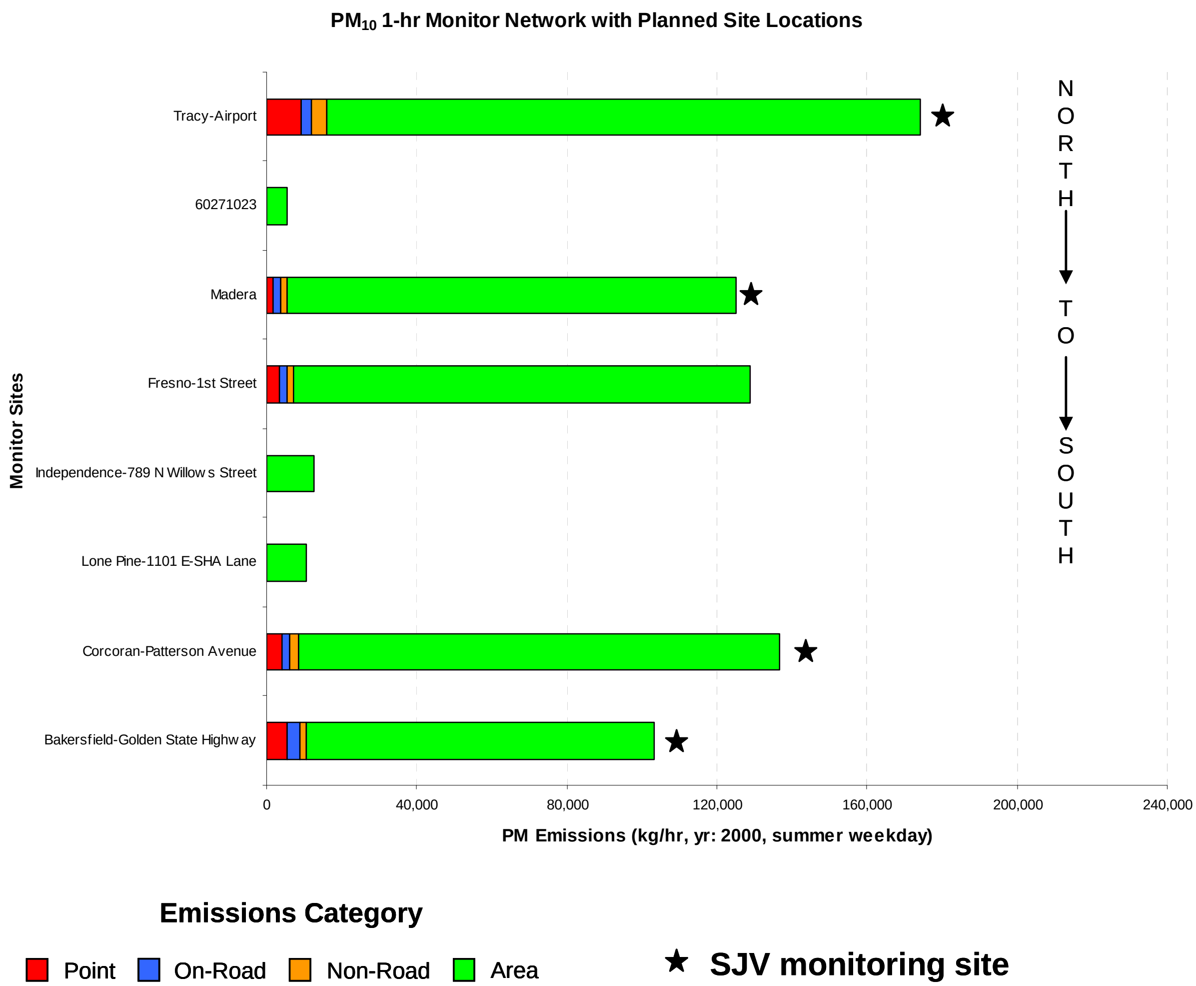
$PM_{2.5}$ 1-hr Monitor Network

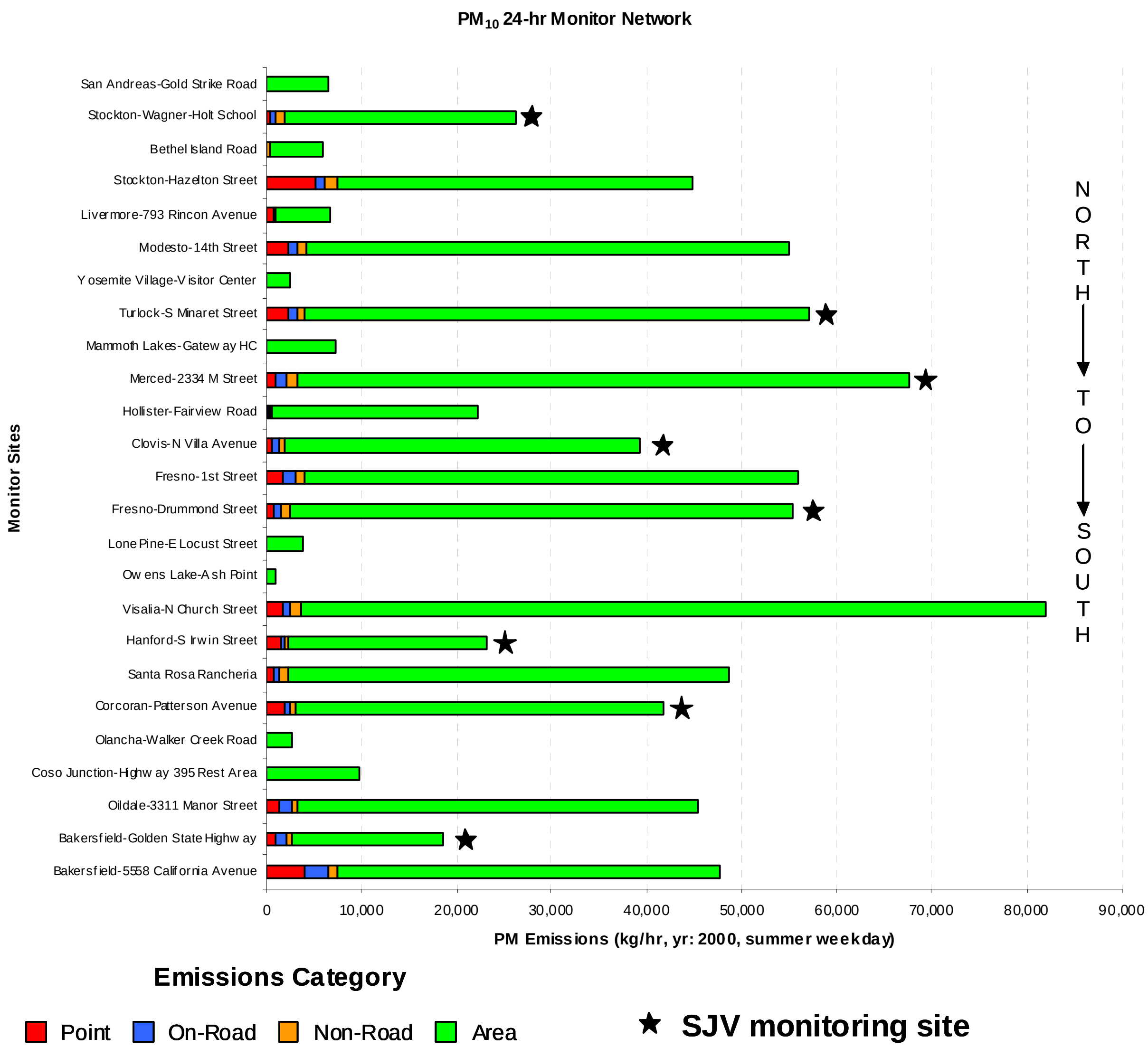



PM2.5 1-hr Monitor Network with Planned Sites
Monitor Sites
Elk Grove-Bruceville Road
Stockton-Hazelton Street
Manteca
Tracy-Airport
Yosemite Village-Visitor Center
Modesto-14th Street
Turlock-S Minaret Street
Madera
Clovis-N Villa Avenue
Fresno-1st Street
Tranquility
Lone Pine-1101 E-SHA Lane
Visalia-N Church Street
Huron
Corcoran-Patterson Avenue
Bakersfield-Golden State Hghway
Bakersfield-5558 California Avenue
Lebec-Peace Valley Road
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
PM Emissions (kg/hr, yr: 2000, summer weekday)
NORTH TO SOUTH
Emissions Category
Point
On-Road
Non-Road
Area
SJV monitoring site


PM2.5 24-hr Monitor Network
Monitor Sites
San Andreas-Gold Strike Road
Stockton-Hazelton Street
Livermore-793 Rincon Avenue
Modesto-14th Street
Merced-2334 M Street
Gilroy-9th Street
Hollister-Fairview Road
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Hamilton and Winery
Keeler-Cerro Gordo Road
Visalia-N Church Street
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
Bakersfield-410 E Planz Road
NORTH TO SOUTH
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
100,000
PM Emissions (kg/hr, yr: 2000, summer weekday)
Emissions Category
Point
On-Road
Non-Road
Area
SJV monitoring site

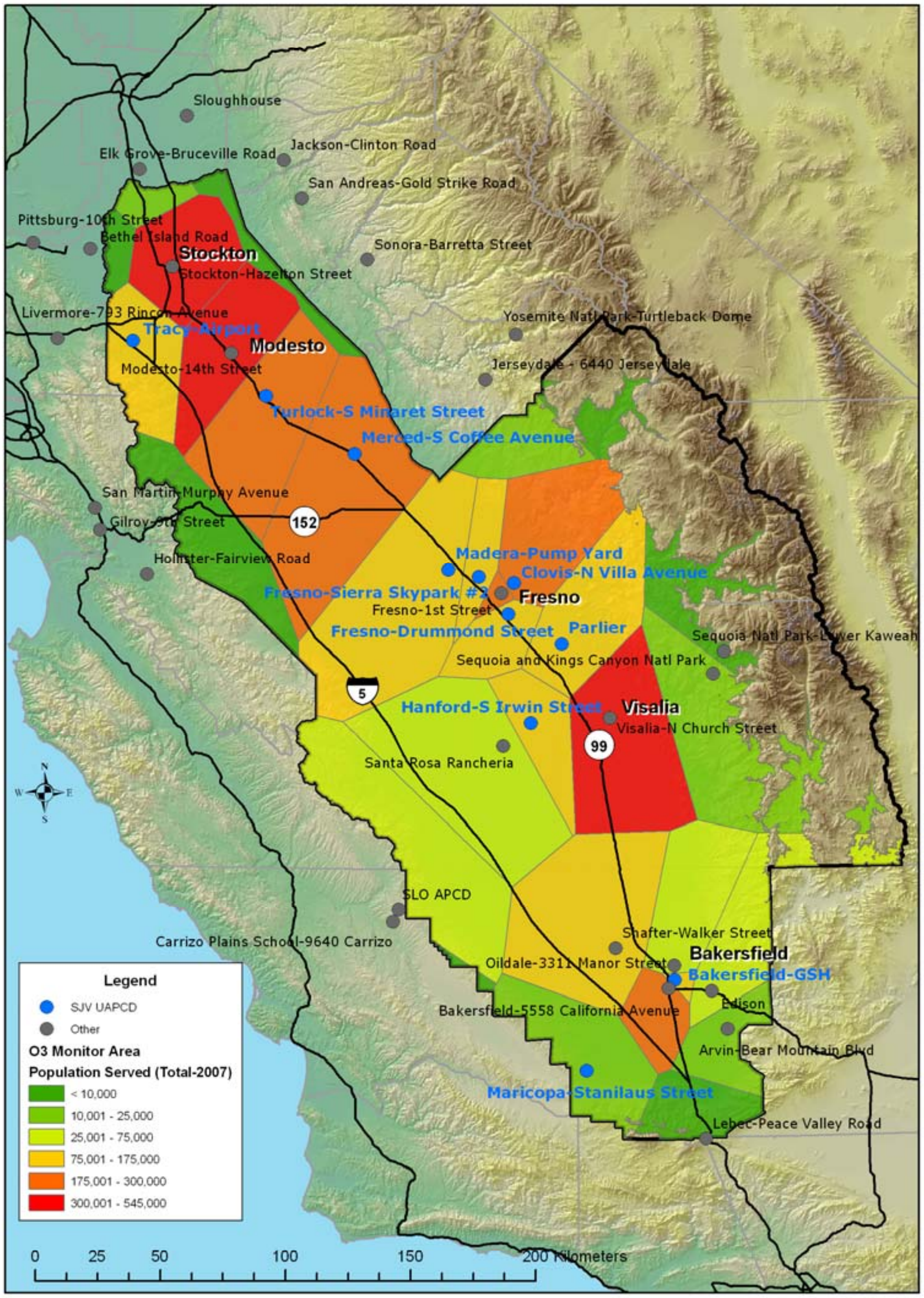

PM10 1-hr Monitor Network
Monitor Sites
Tracy-Airport
60271023
Fresno-1st Street
Independence-789 N Willows Street
Lone Pine-1101 E-SHA Lane
Corcoran-Patterson Avenue
Bakersfield-Golden State Highway
0
40,000
80,000
120,000
160,000
200,000
240,000
PM Emissions (kg/hr, yr: 2000, summer weekday)
NORTH TO SOUTH
Emissions Category
Point
On-Road
Non-Road
Area
★ SJV monitoring site


PM10 1-hr Monitor Network with Planned Site Locations
Monitor Sites
Tracy-Airport
60271023
Madera
Fresno-1st Street
Independence-789 N Willow s Street
Lone Pine-1101 E-SHA Lane
Corcoran-Patterson Avenue
Bakersfield-Golden State Highw ay
0
40,000
80,000
120,000
160,000
200,000
240,000
PM Emissions (kg/hr, yr: 2000, summer weekday)
NORTH TO SOUTH
Emissions Category
Point
On-Road
Non-Road
Area
SJV monitoring site

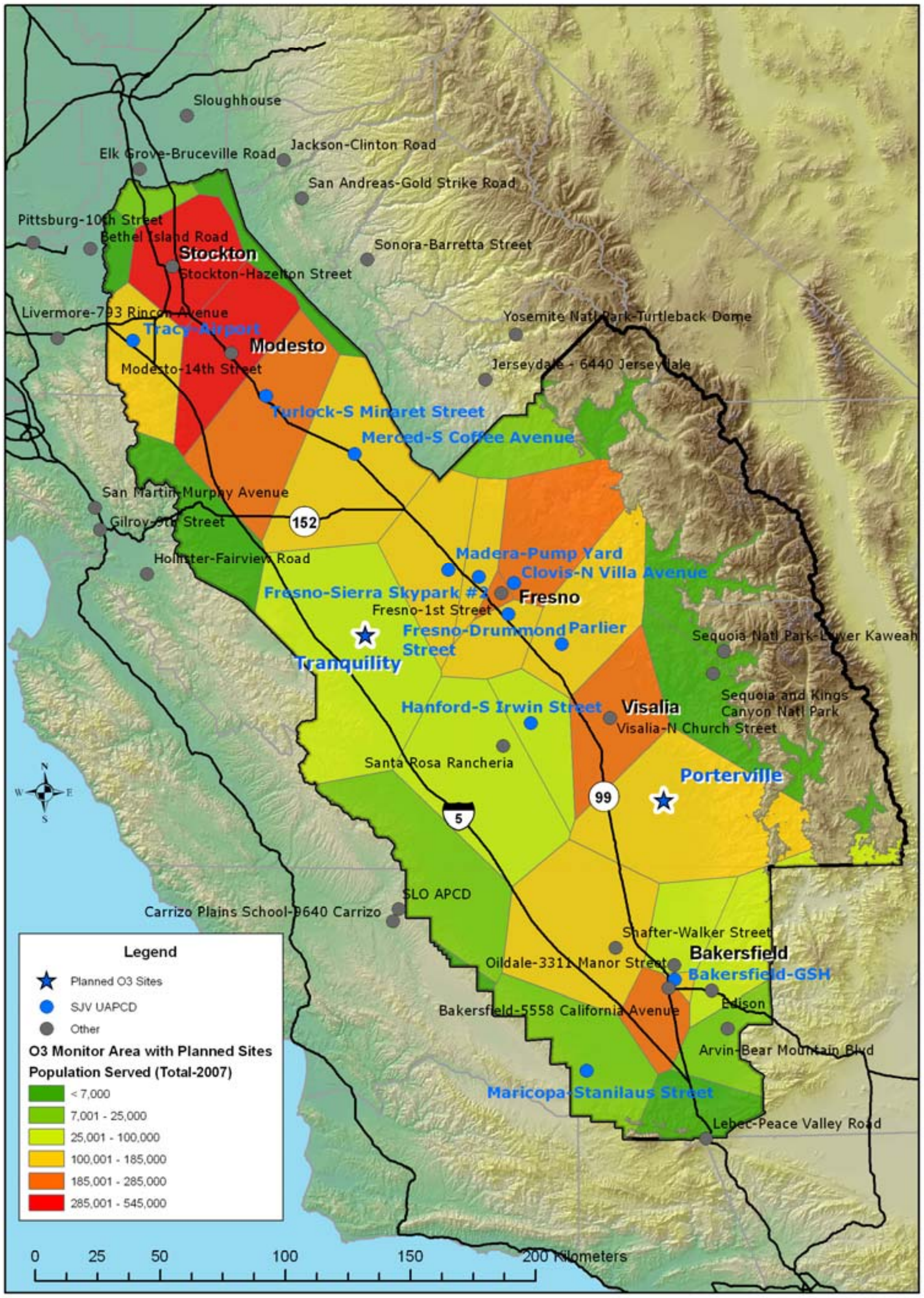


PM10 24-hr Monitor Network
Monitor Sites
San Andreas-Gold Strike Road
Stockton-Wagner-Holt School
Bethel Island Road
Stockton-Hazelton Street
Livermore-793 Rincon Avenue
Modesto-14th Street
Yosemite Village-Visitor Center
Turlock-S Minaret Street
Mammoth Lakes-Gateway HC
Merced-2334 M Street
Hollister-Fairview Road
Clovis-N Villa Avenue
Fresno-1st Street
Fresno-Drummond Street
Lone Pine-E Locust Street
Owens Lake-Ash Point
Visalia-N Church Street
Hanford-S Irwin Street
Santa Rosa Rancheria
Corcoran-Patterson Avenue
Olancha-Walker Creek Road
Coso Junction-Highway 395 Rest Area
Oildale-3311 Manor Street
Bakersfield-Golden State Highway
Bakersfield-5558 California Avenue
0
10,000
20,000
30,000
40,000
50,000
60,000
70,000
80,000
90,000
PM Emissions (kg/hr, yr: 2000, summer weekday)
NORTH TO SOUTH
Emissions Category
Point
On-Road
Non-Road
Area
SJV monitoring site

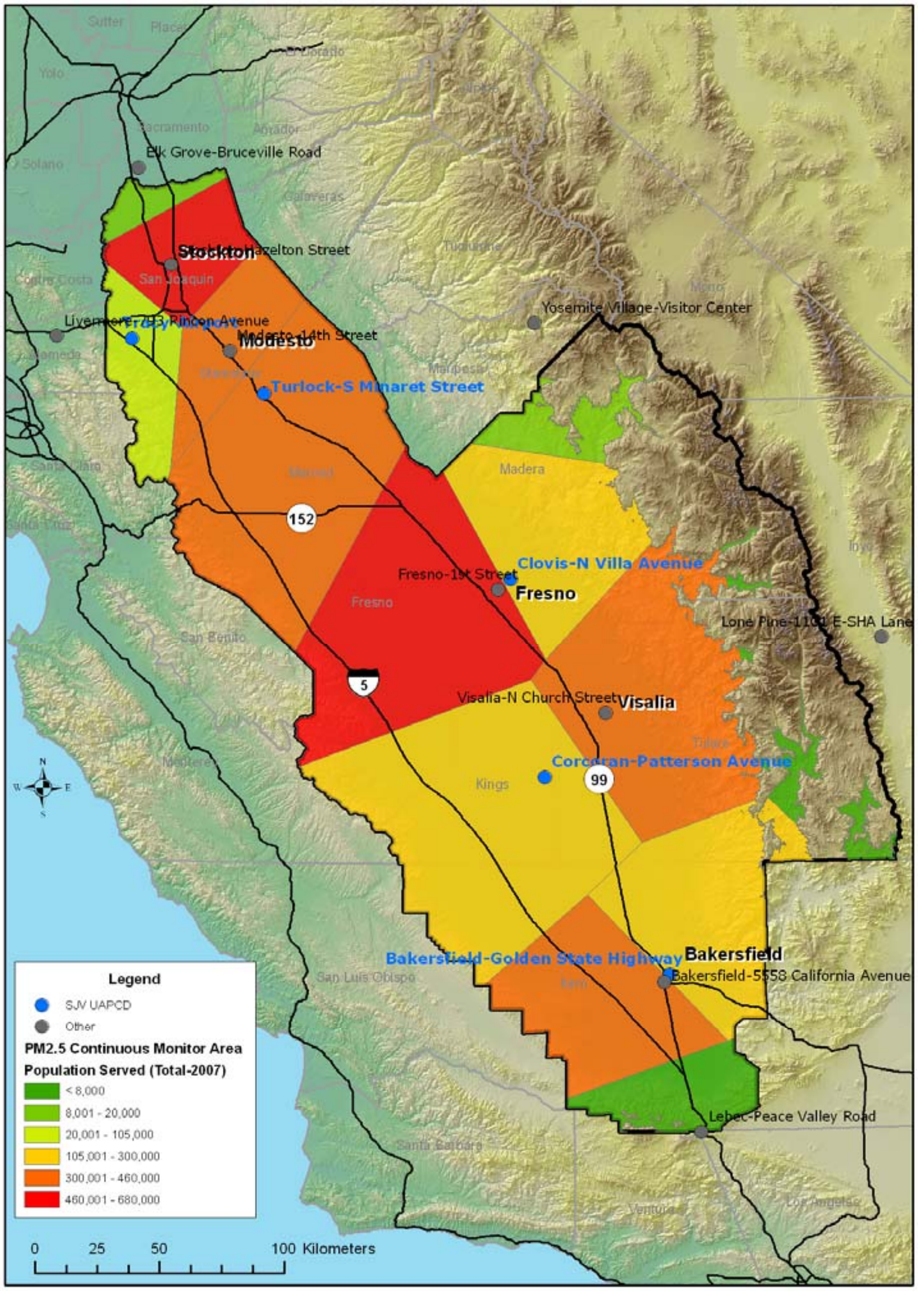
POPULATION SERVED MAPS



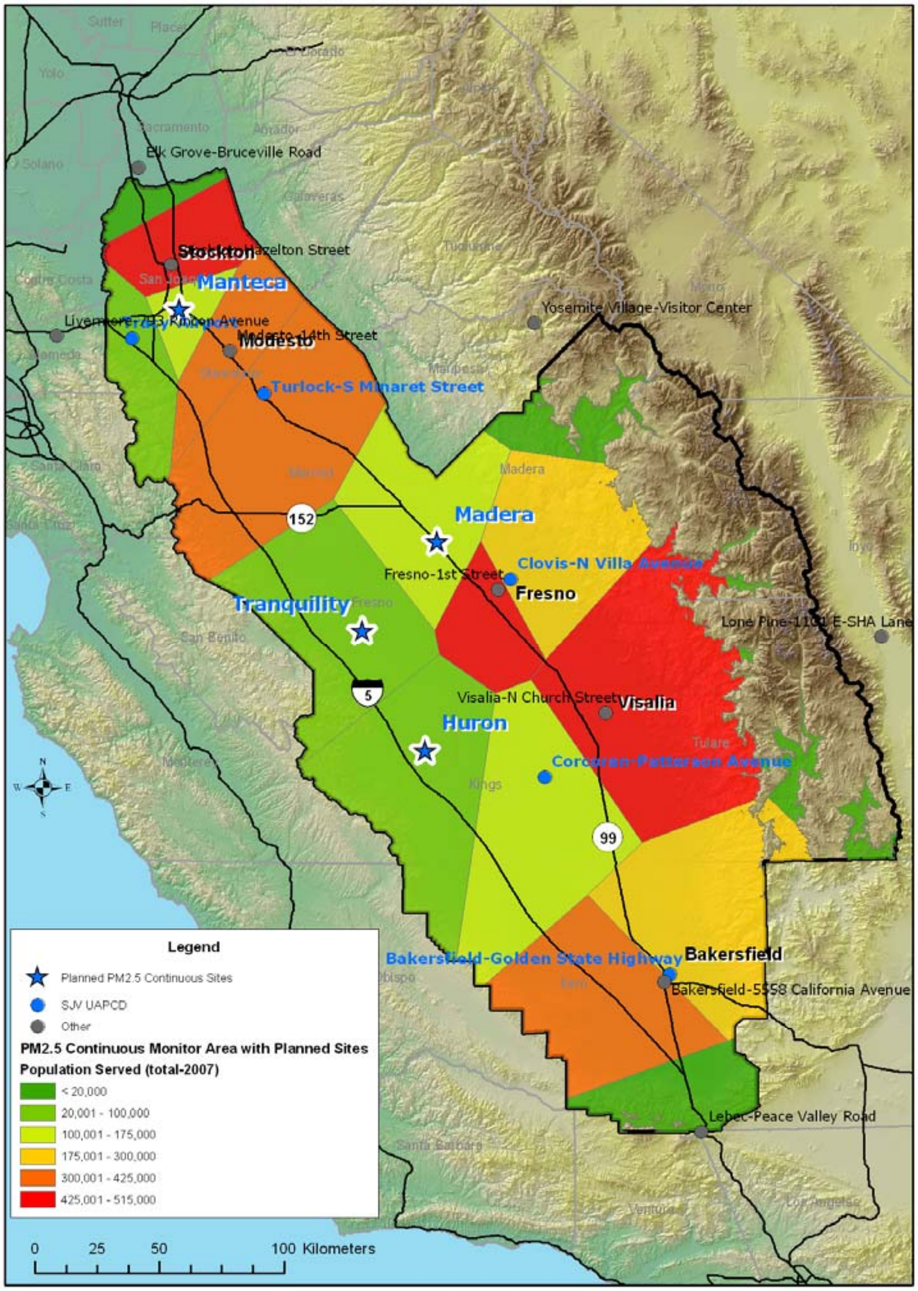
Population served for O_3 monitor areas



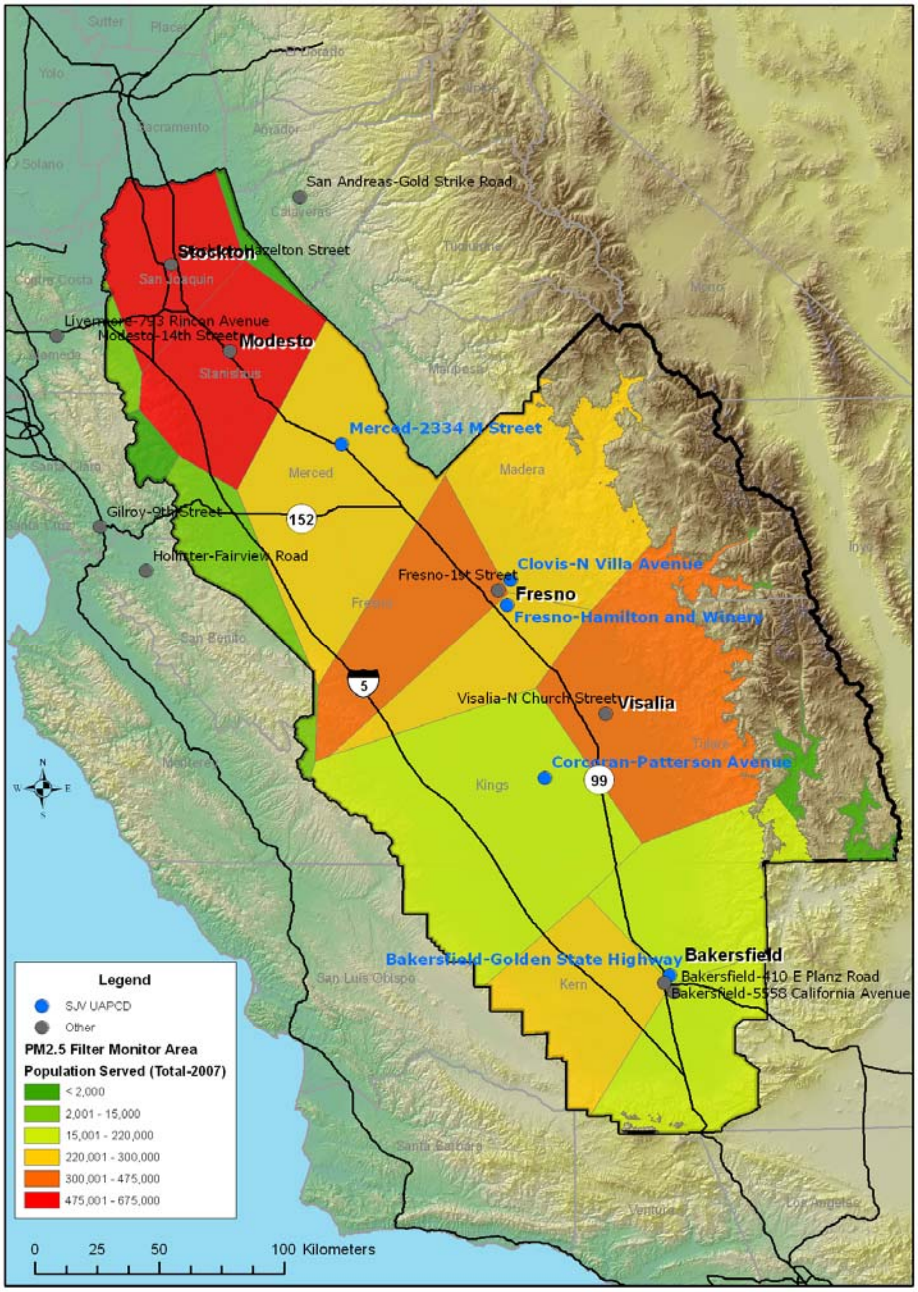
Population served for O_3 monitor areas, including planned site locations



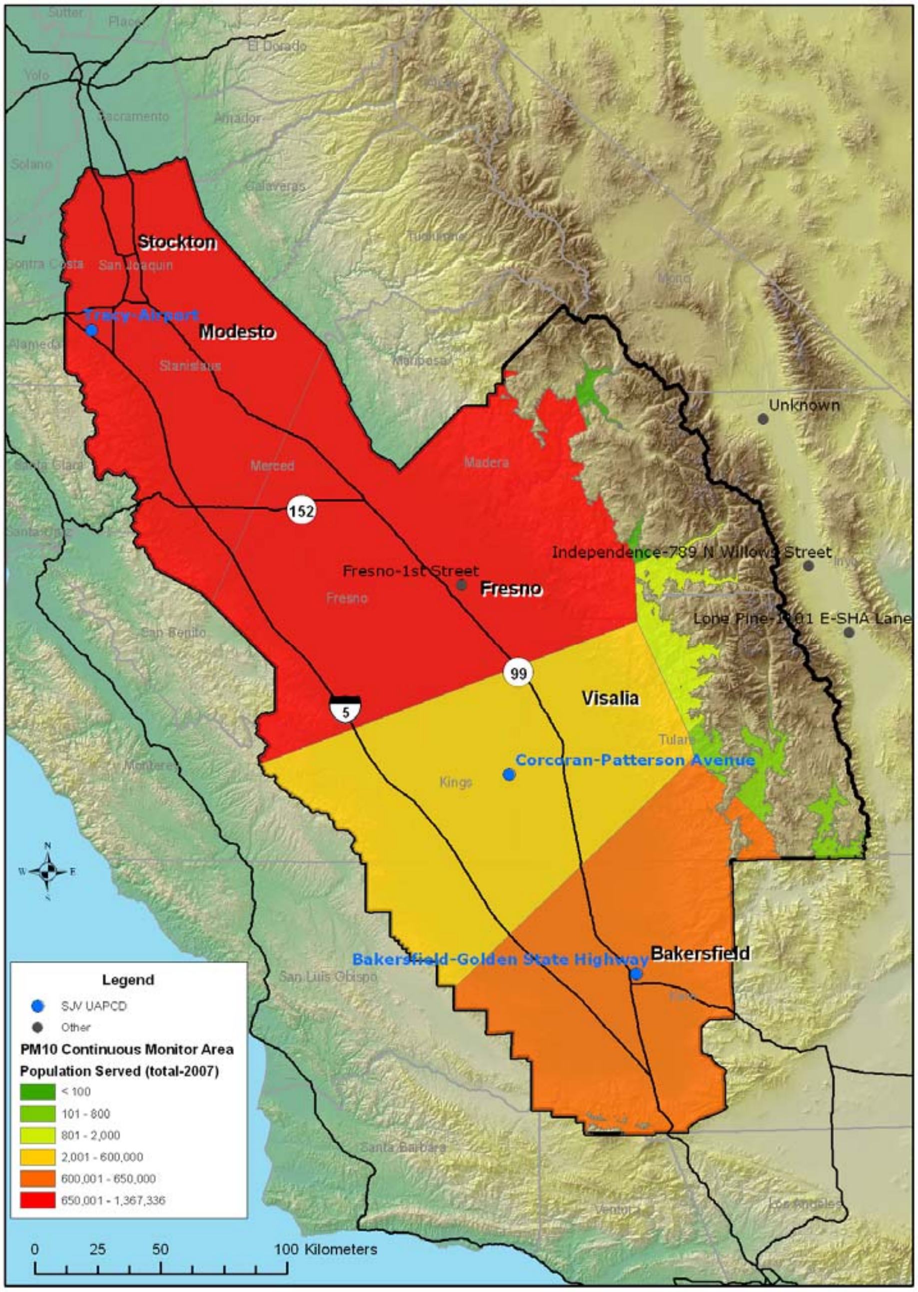
Population served for $PM_{2.5}$-1hr monitor areas



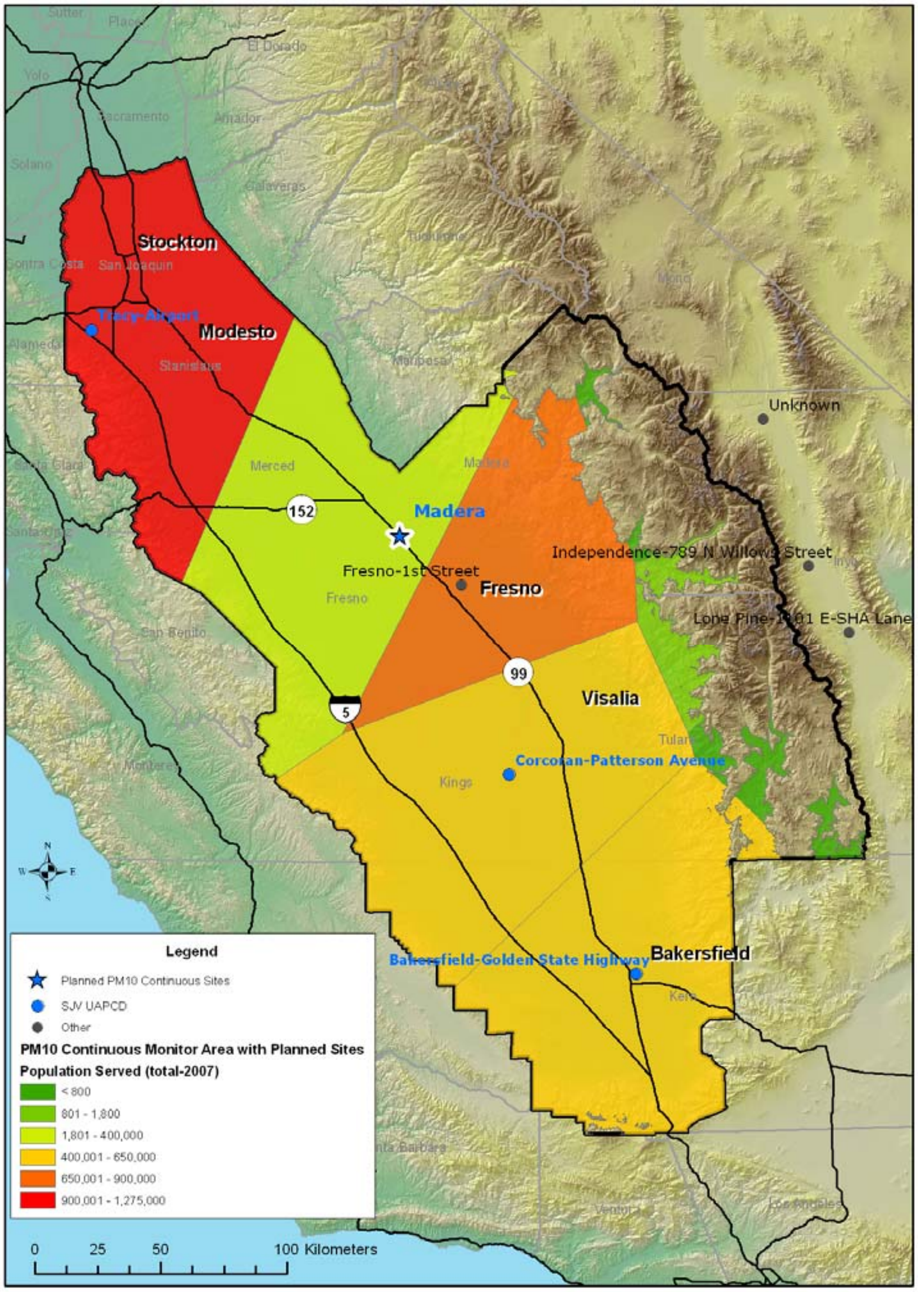
Population served for $PM_{2.5}$-1hr monitor areas, including planned site locations



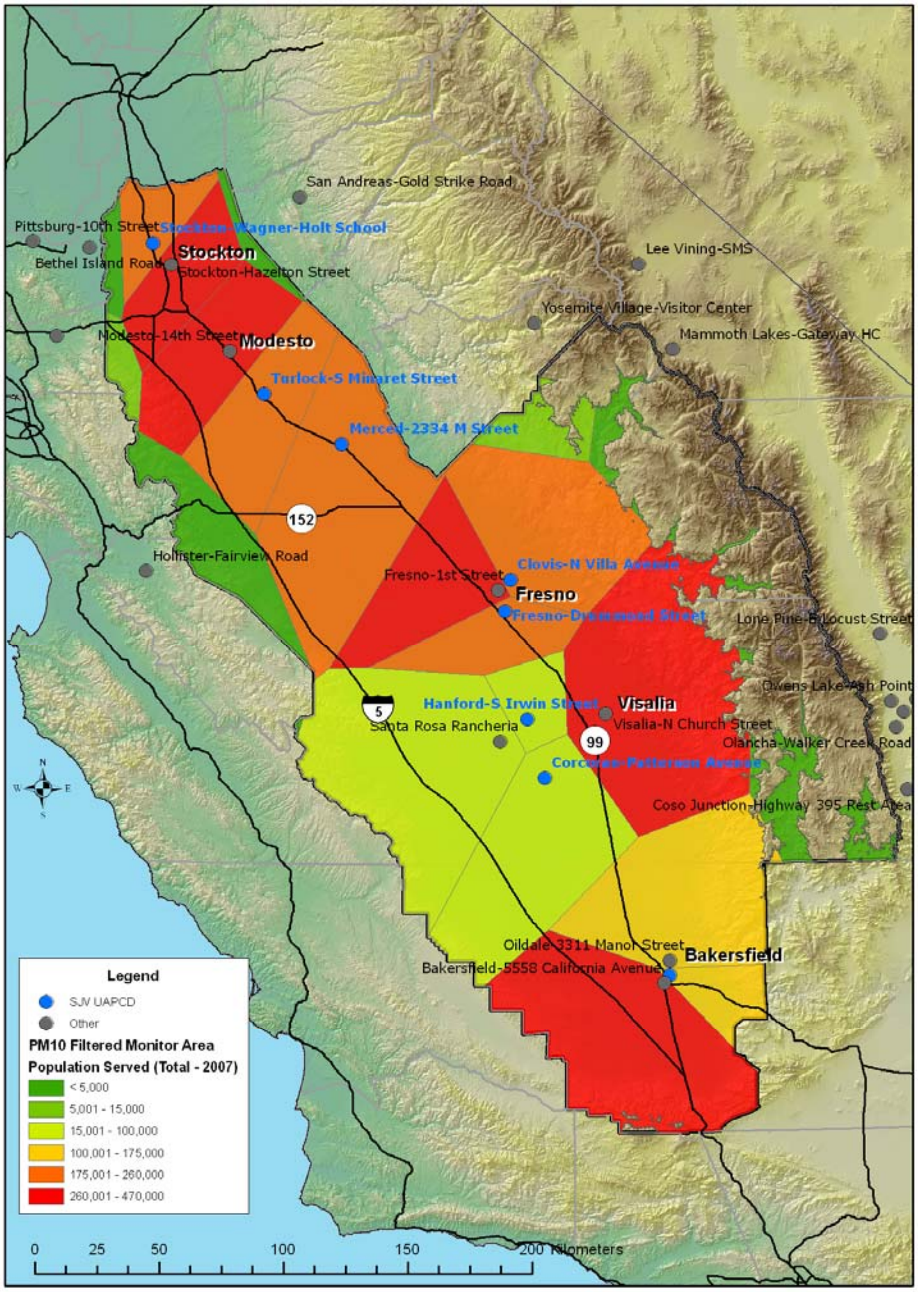
Population served for $PM_{2.5}$-24hr monitor areas



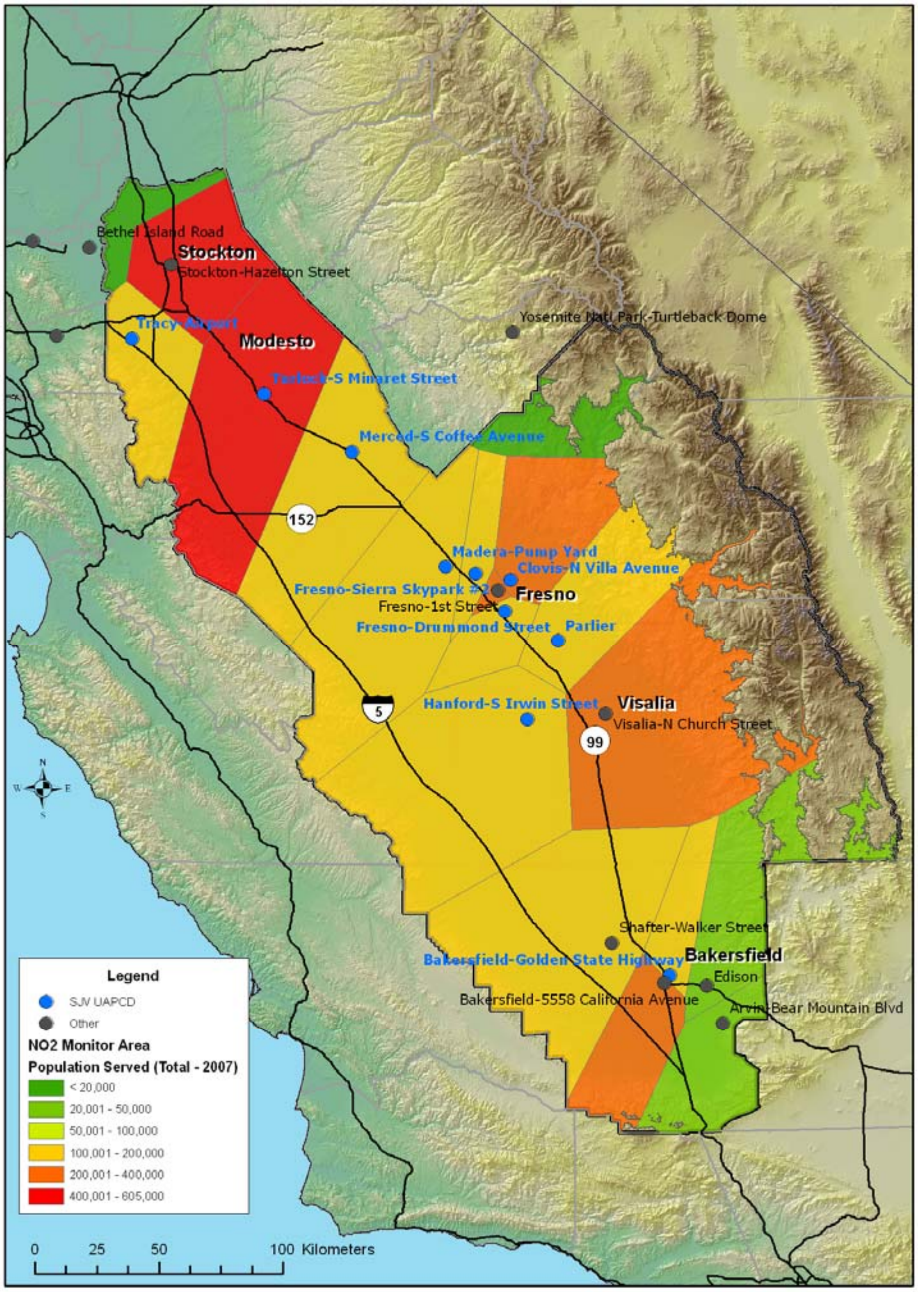
Population served for PM_{10}-1hr monitor areas



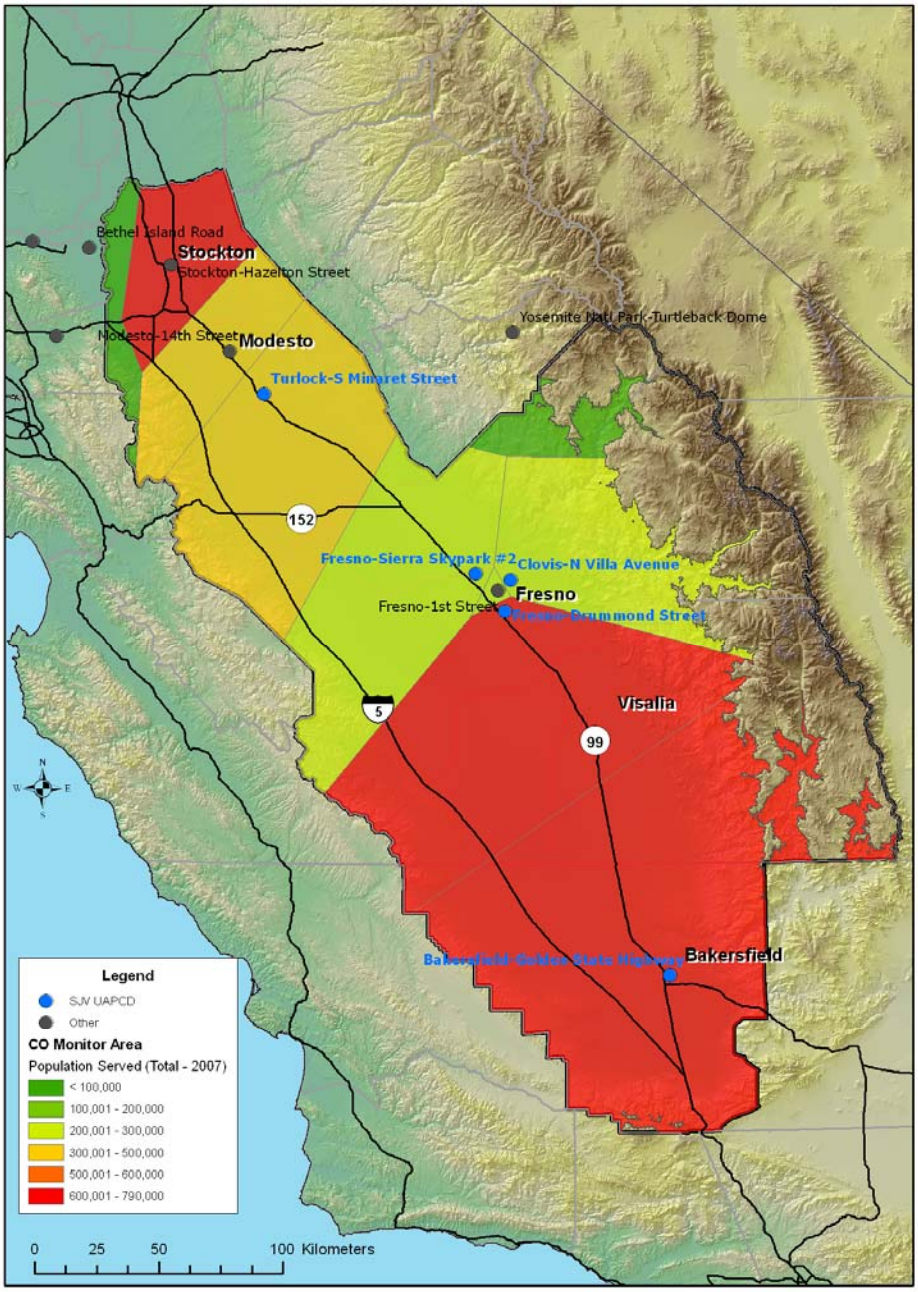
Population served for PM_{10}-1hr monitor areas, including planned site locations



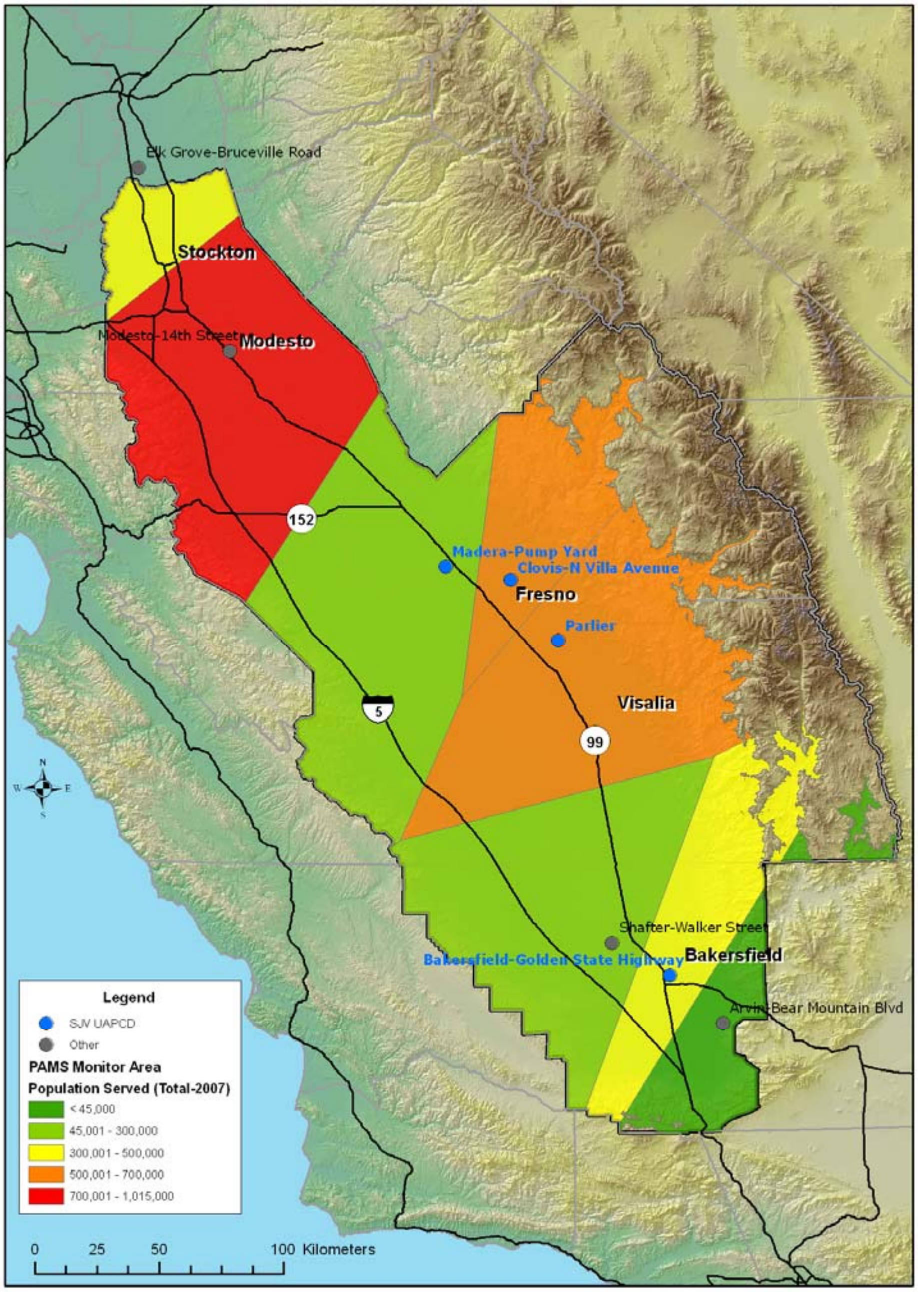
Population served for PM_{10}-24hr monitor areas



Population served for NO_2 monitor areas

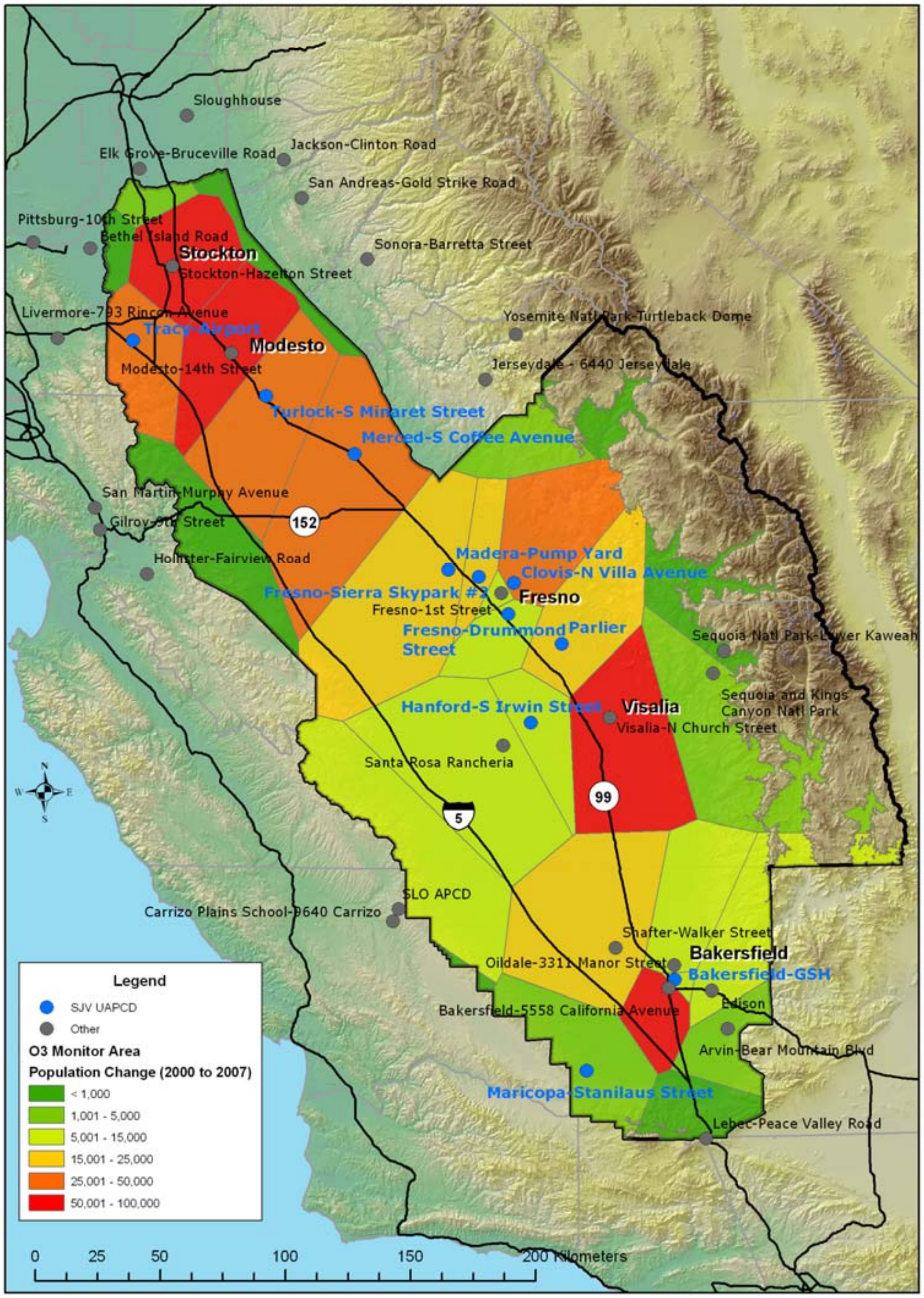


Population served for CO monitor areas

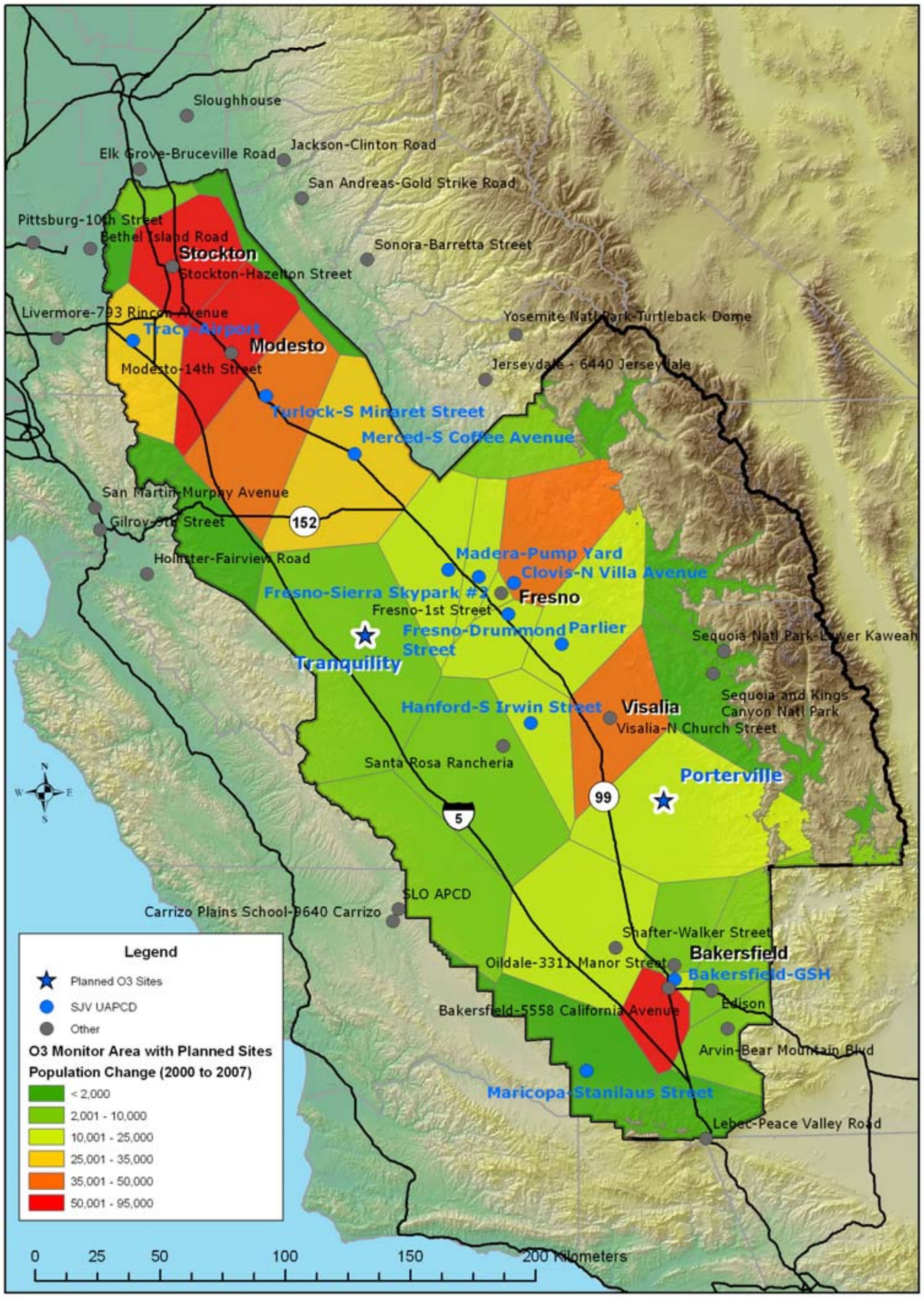


Population served for PAMS monitor areas

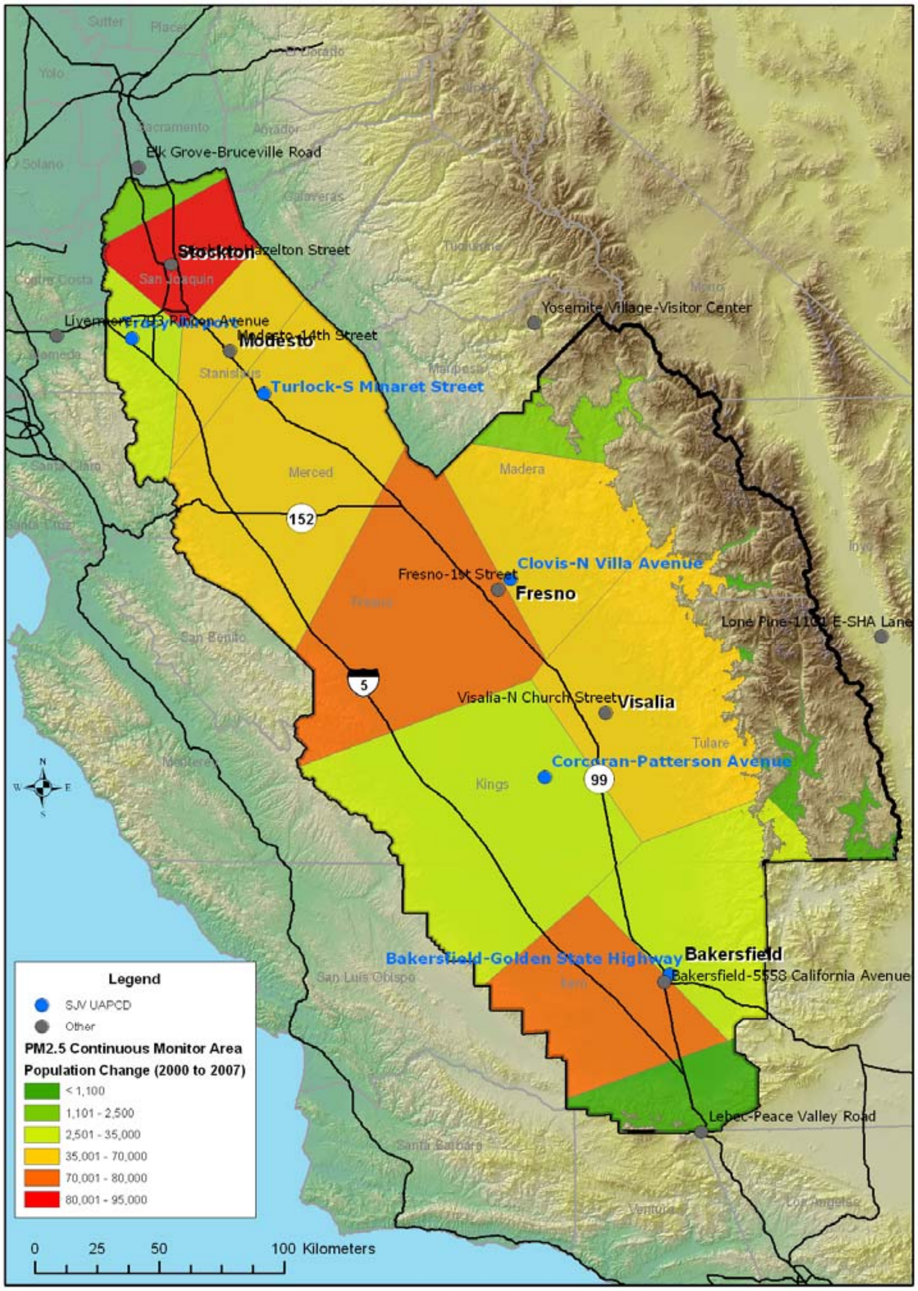
POPULATION CHANGE MAPS



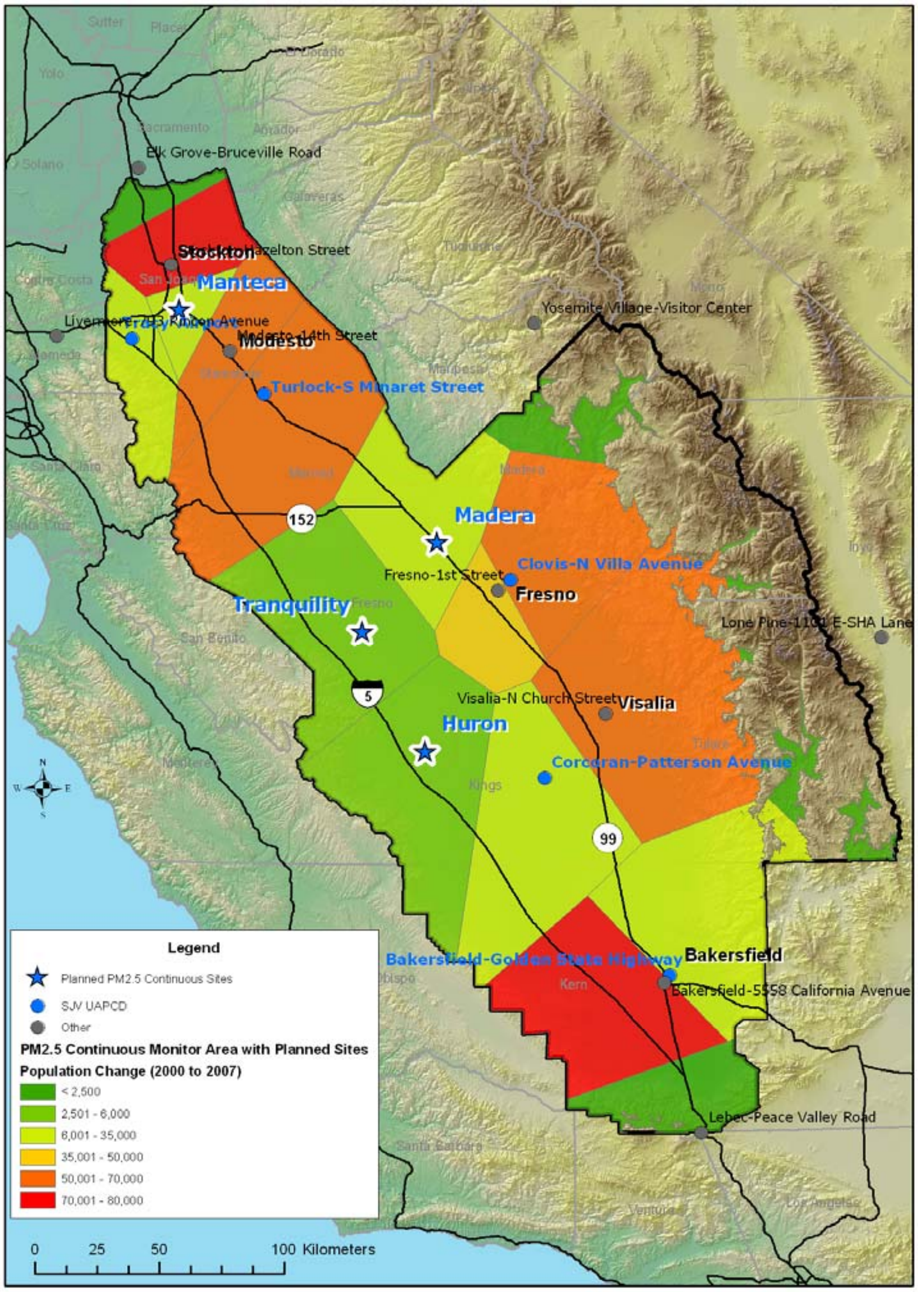
Population change served for O_3 monitor areas



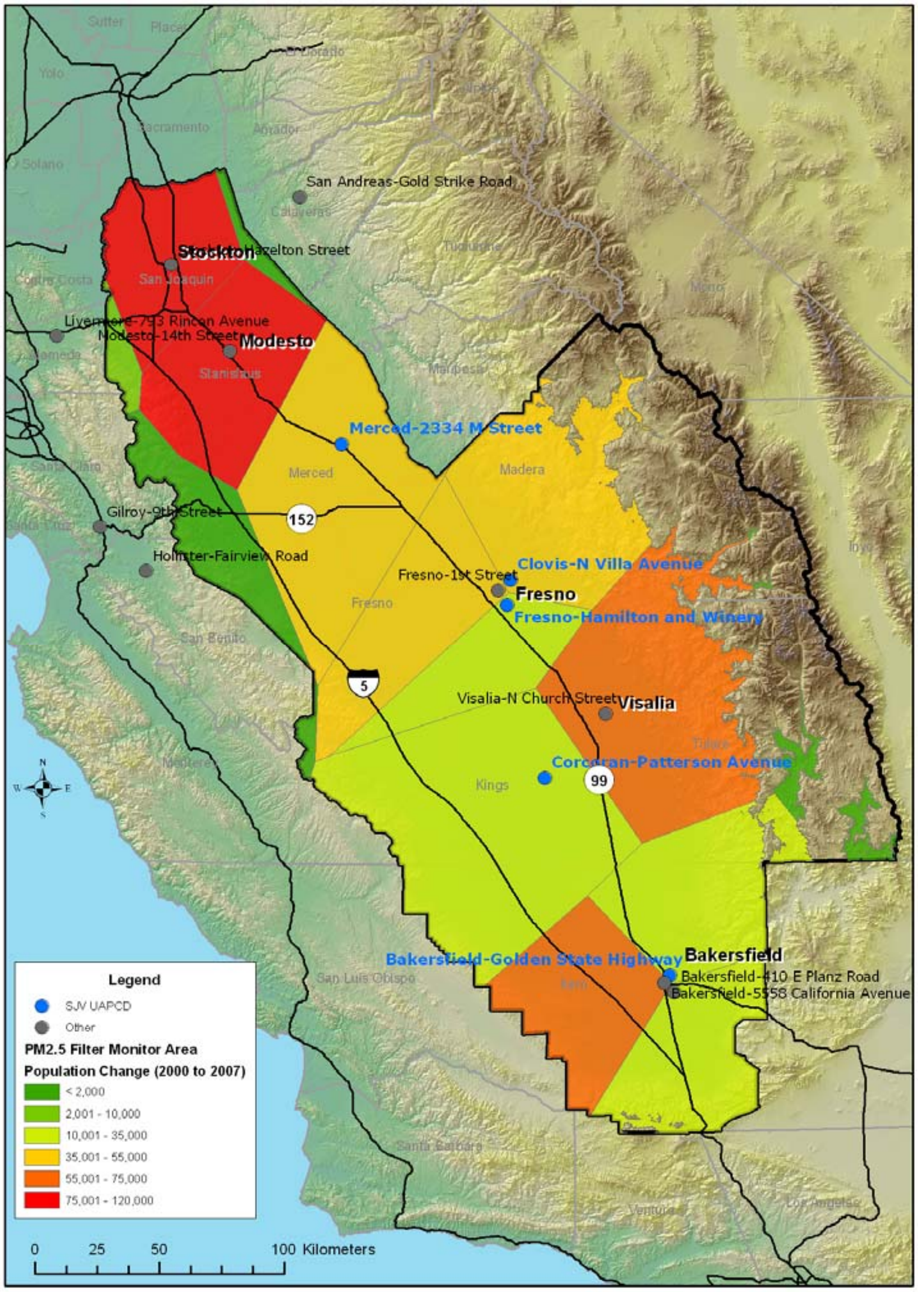
Population change served for O_3 monitor areas, including planned site locations



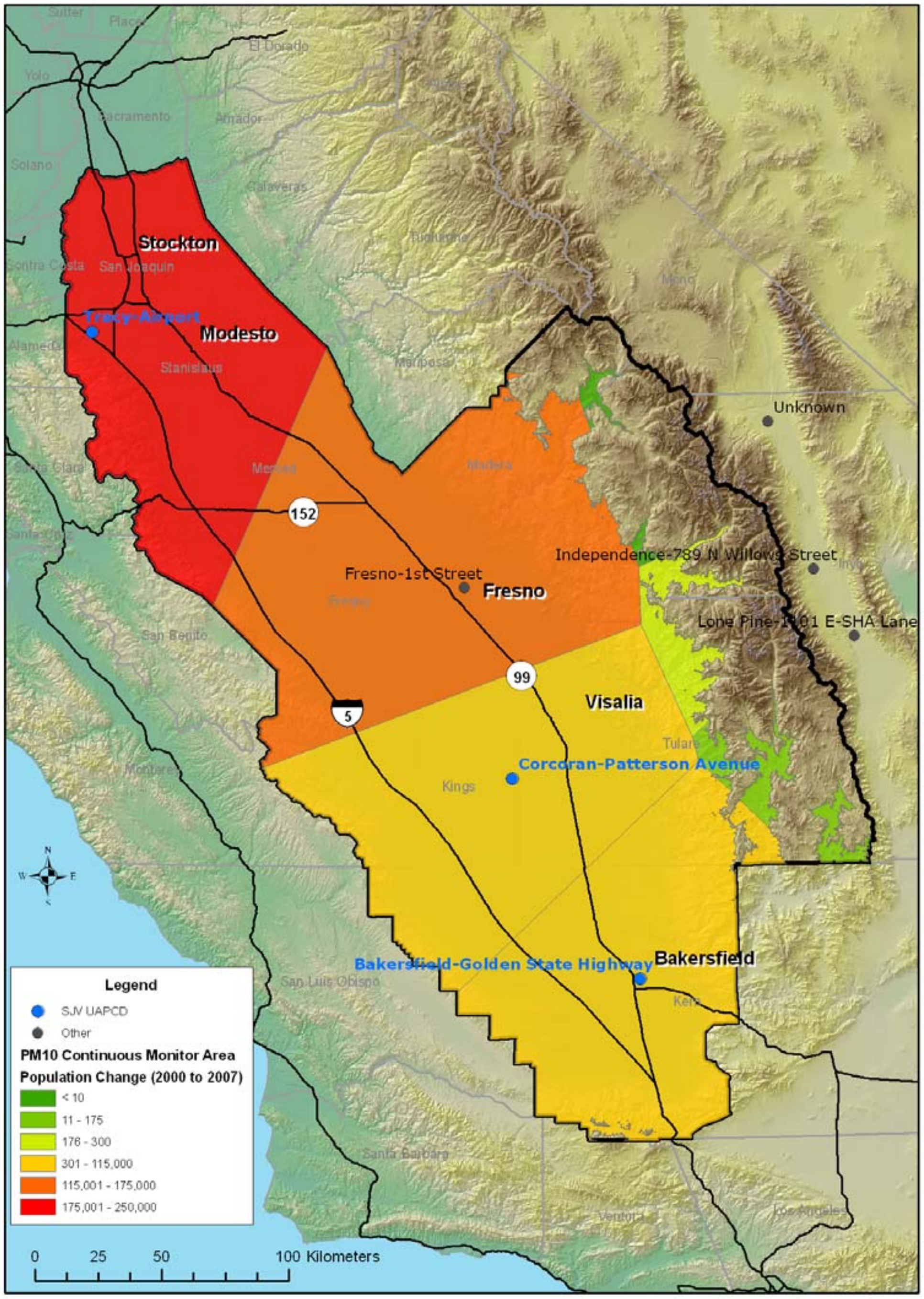
Population change served for $PM_{2.5}$-1hr monitor areas



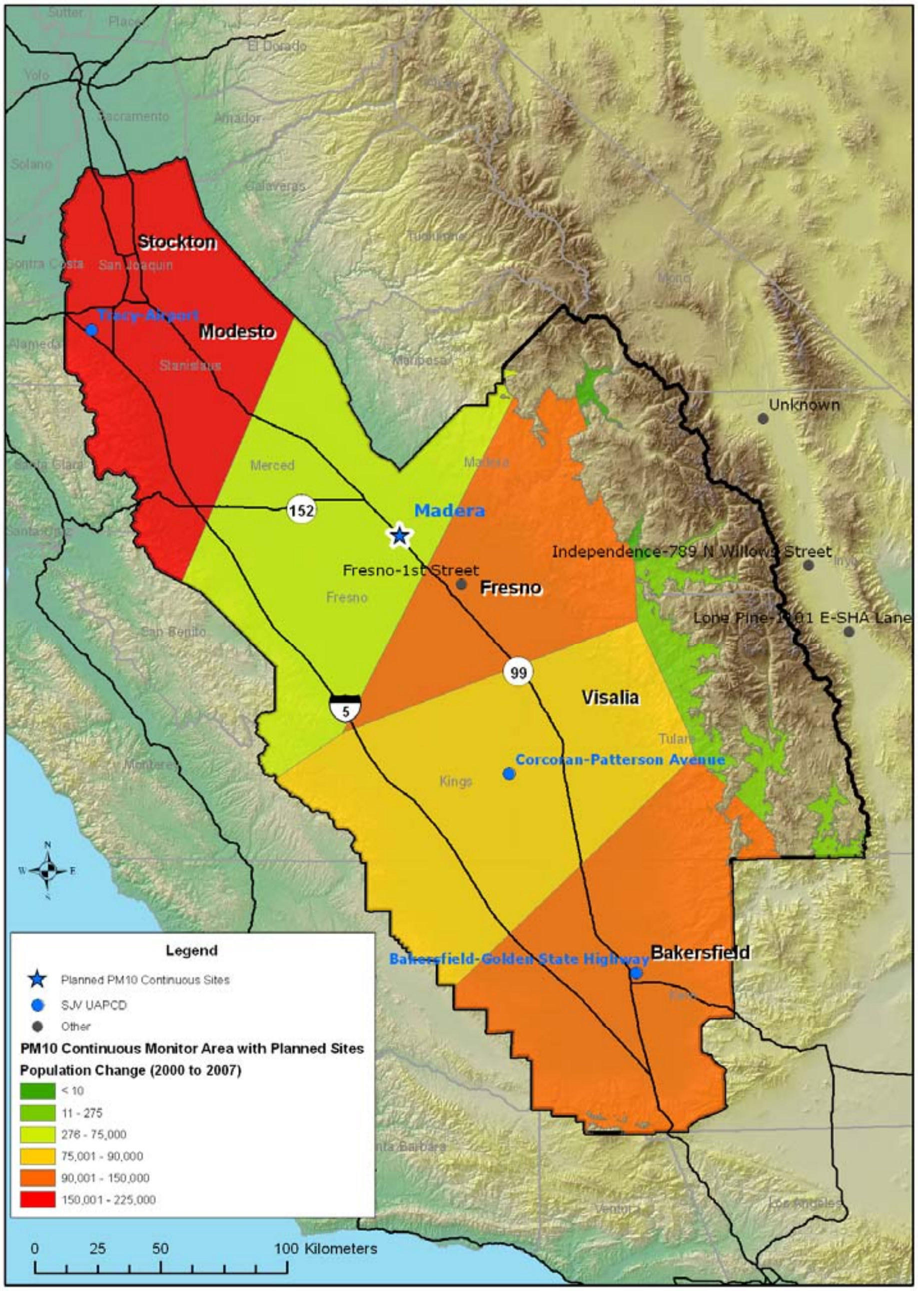
Population change served for $PM_{2.5}$-1hr monitor areas, including planned site locations



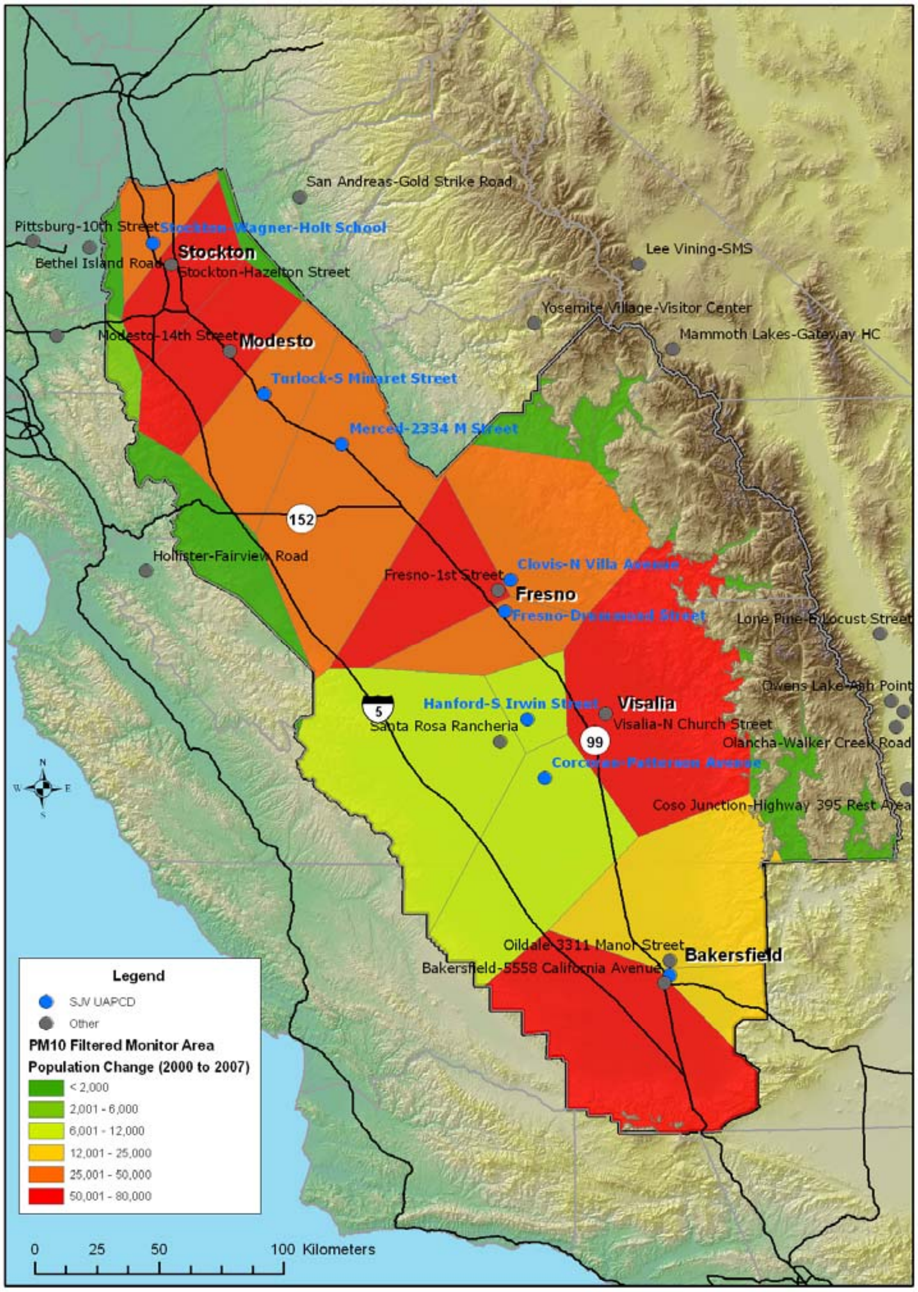
Population change served for $PM_{2.5}$-24hr monitor areas



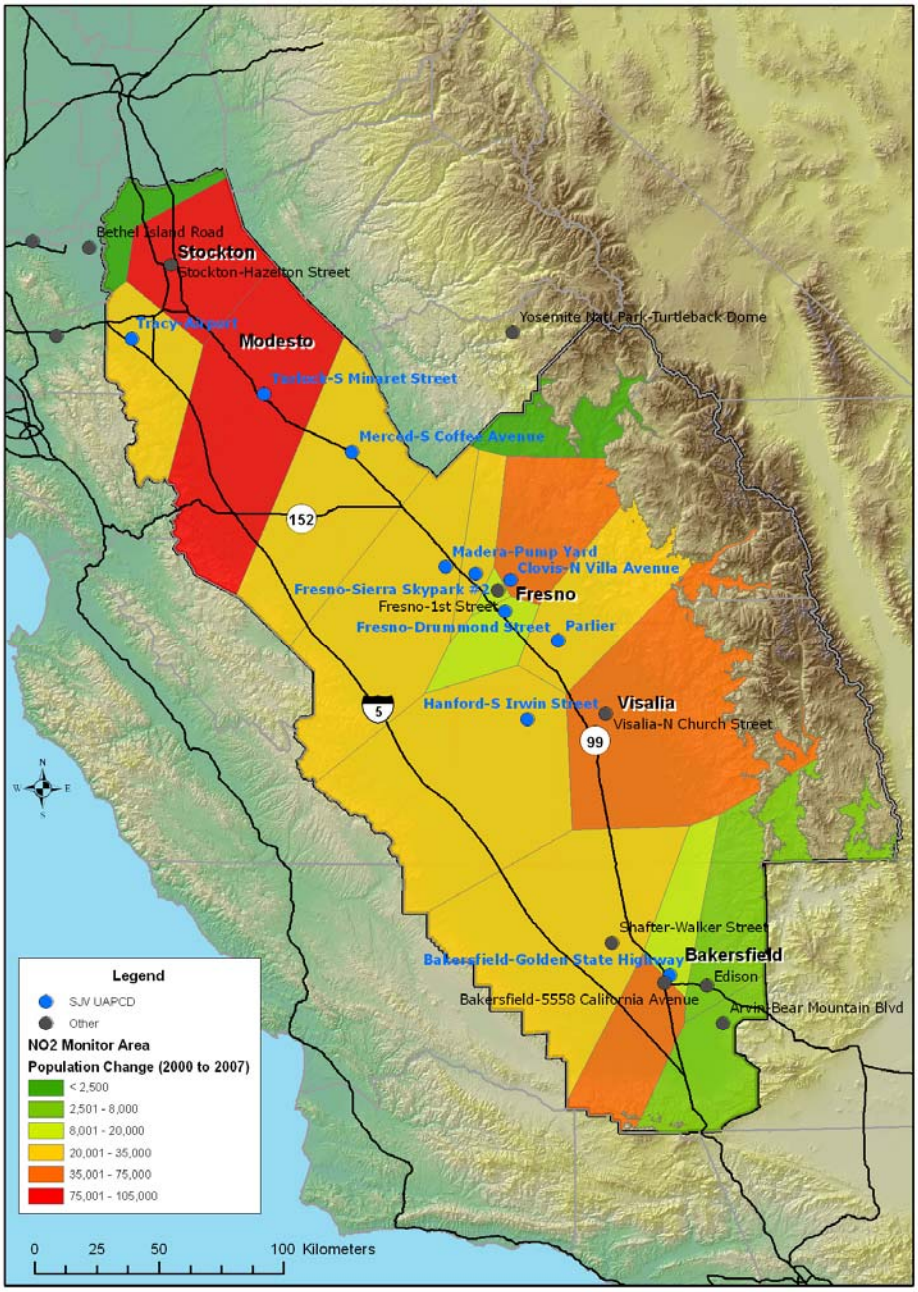
Population change served for PM_{10}-1hr monitor areas



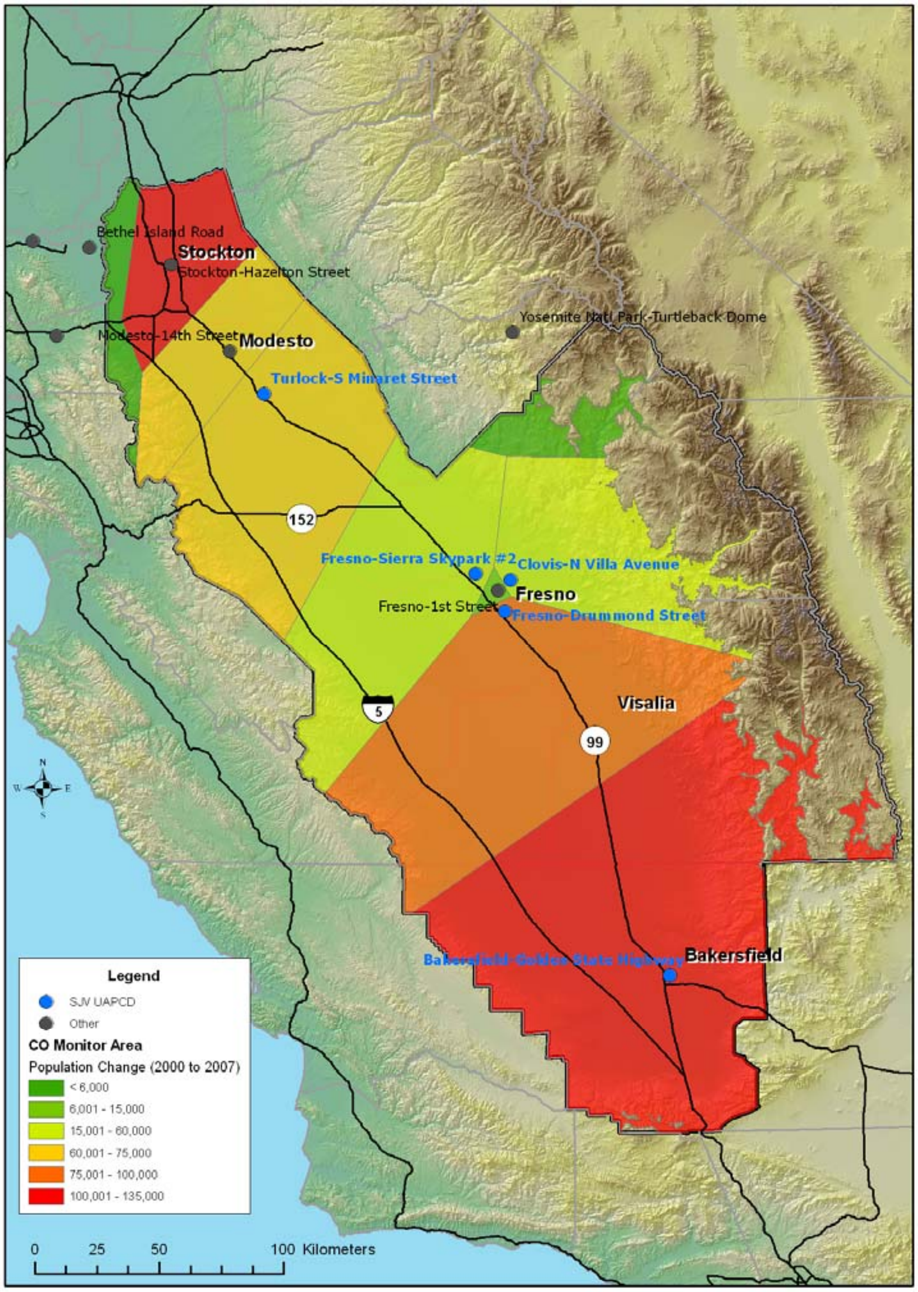
Population change served for PM10-1hr monitor areas, including planned site locations



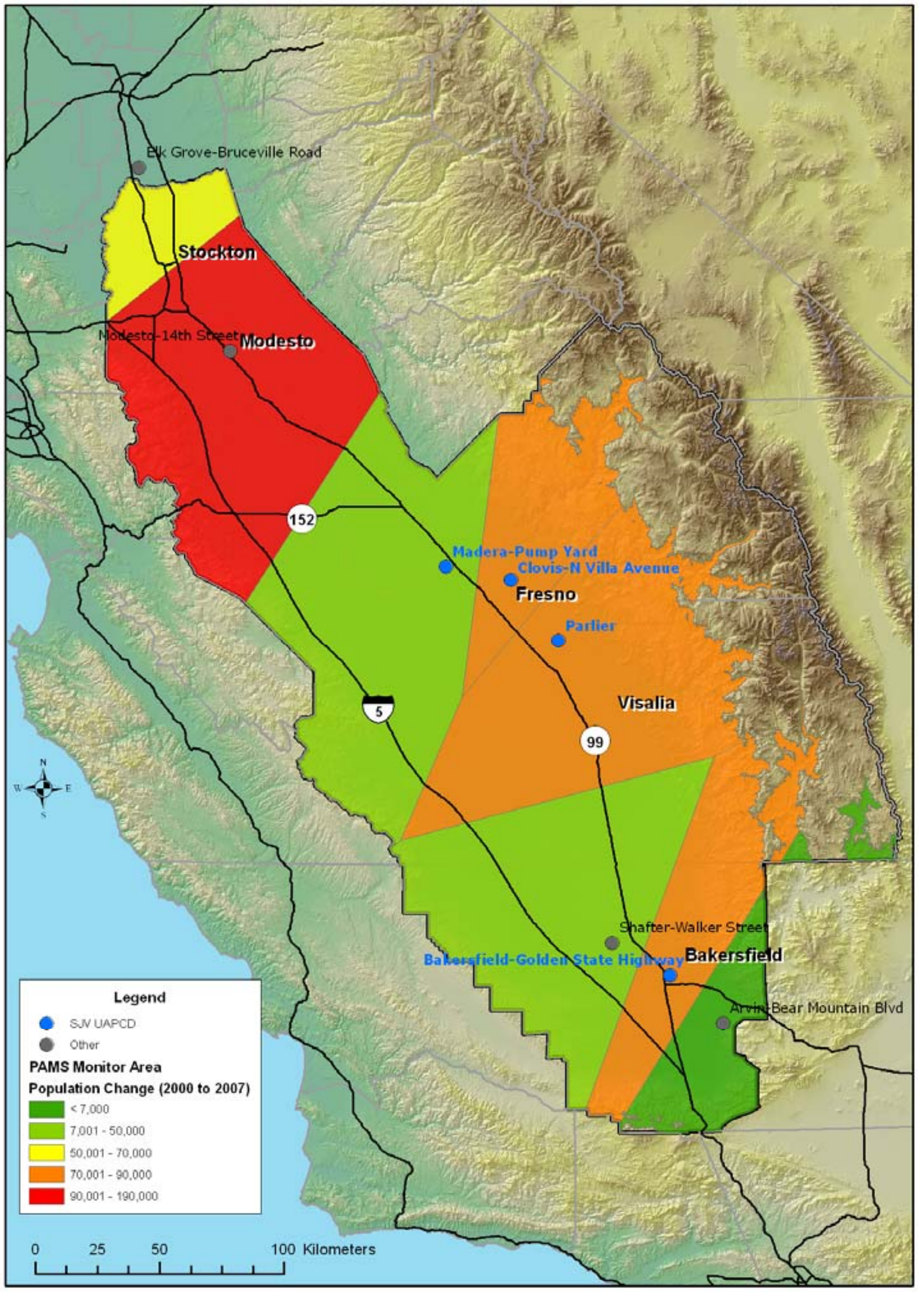
Population change served for PM_{10}-24hr monitor areas



Population change served for NO_2 monitor areas

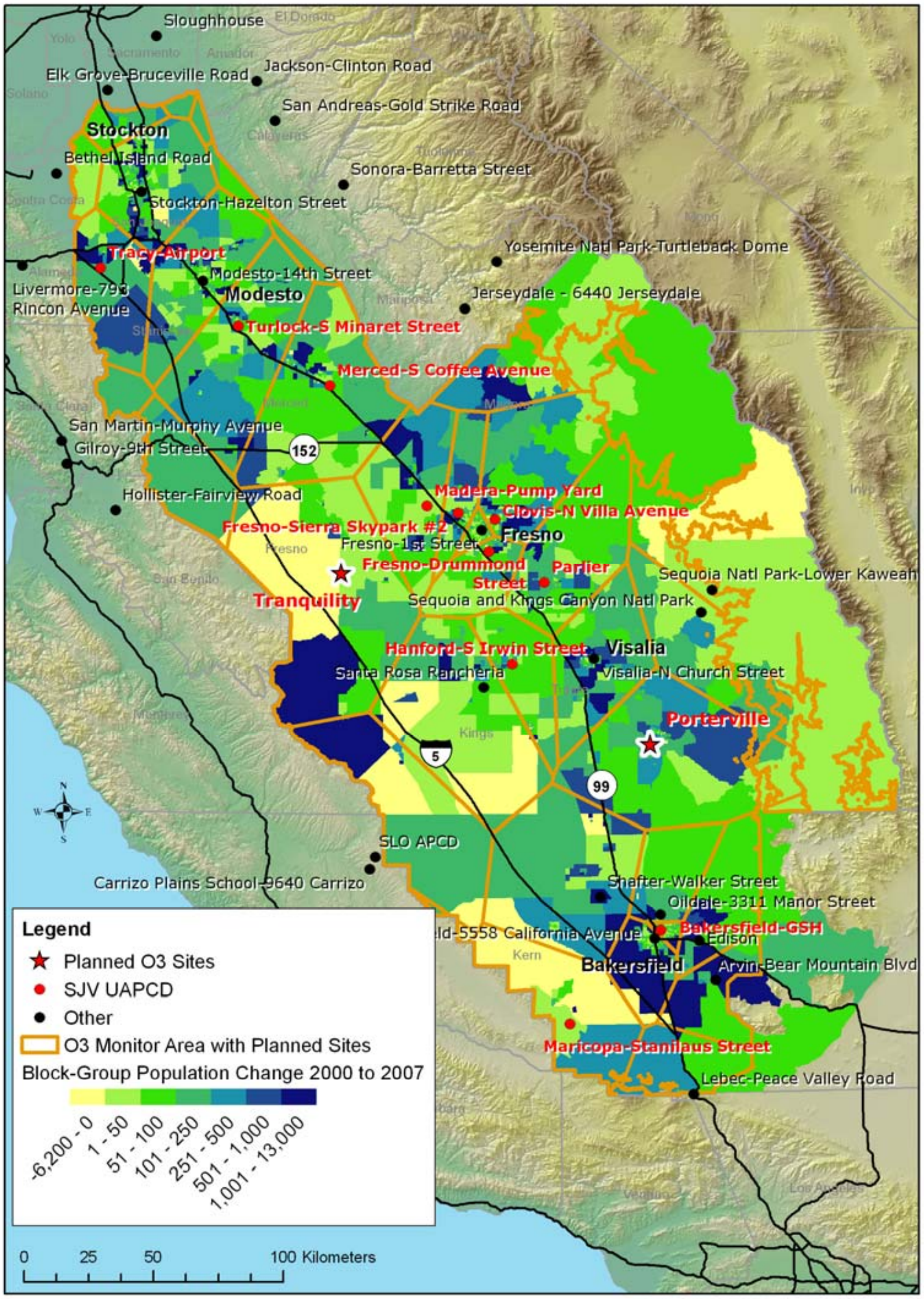


Population change served for CO monitor areas

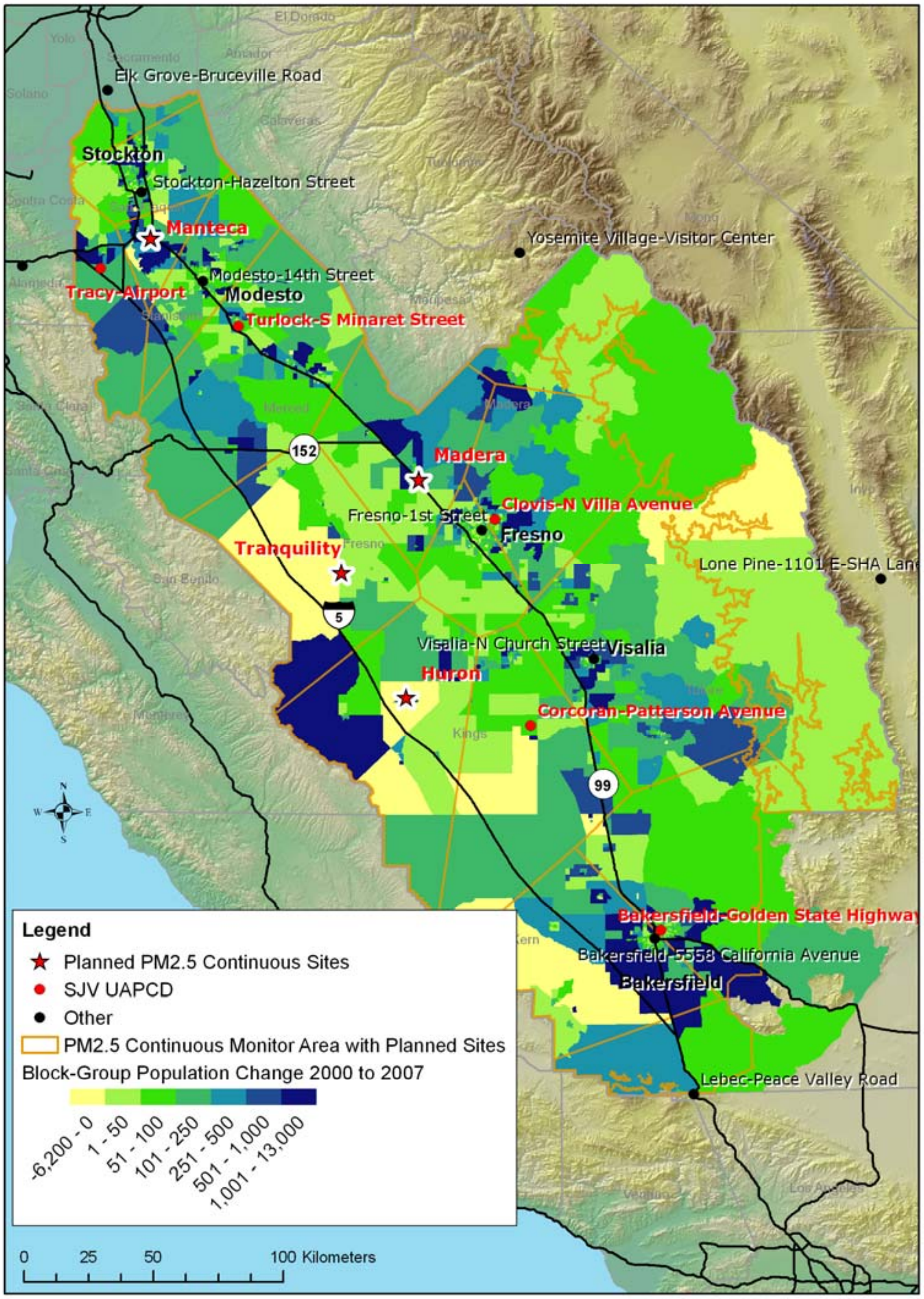


Population change served for PAMS monitor areas

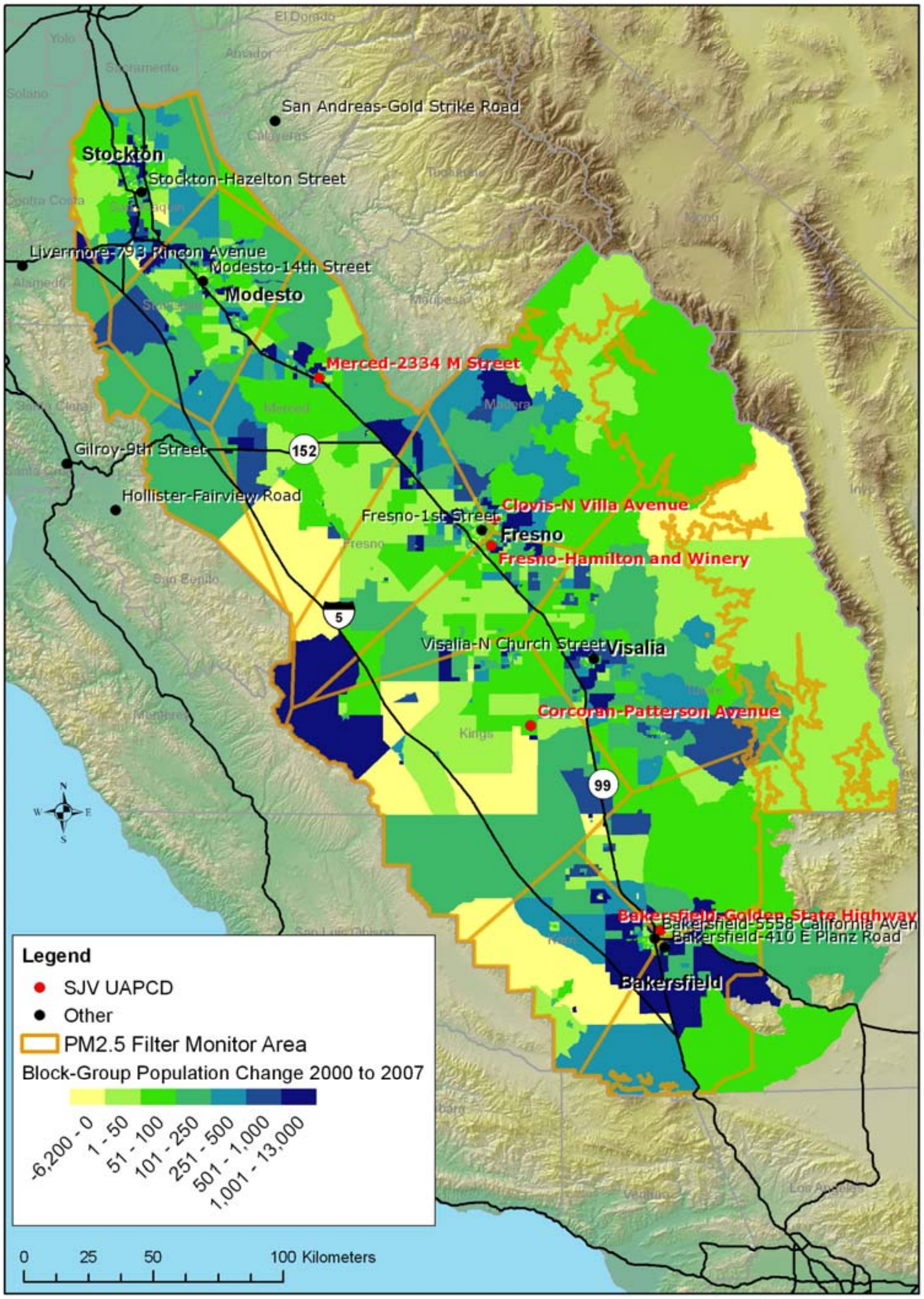
BLOCK-GROUP POPULATION CHANGE MAPS



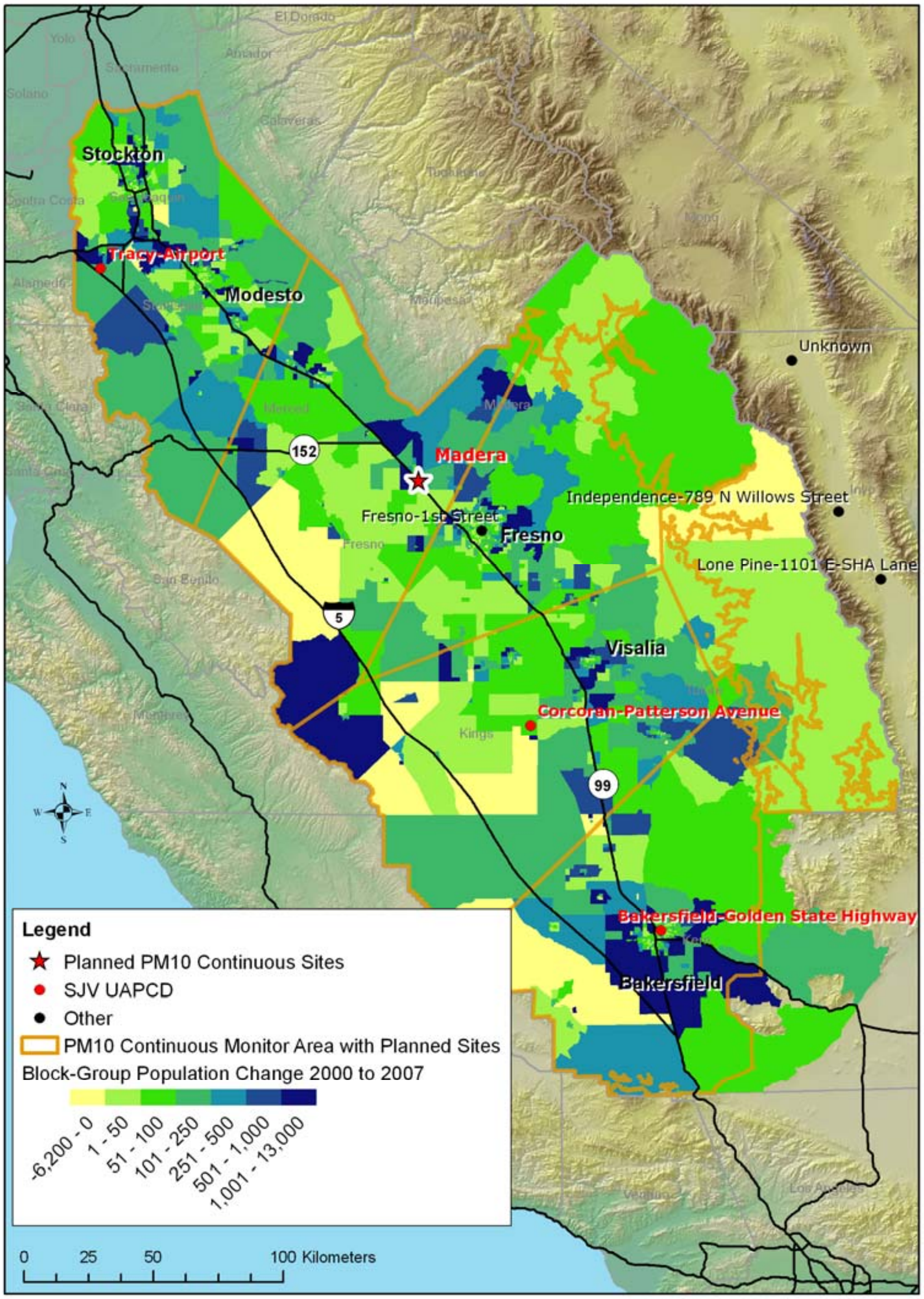
Block-group population change for O_3 monitor areas, including planned site locations



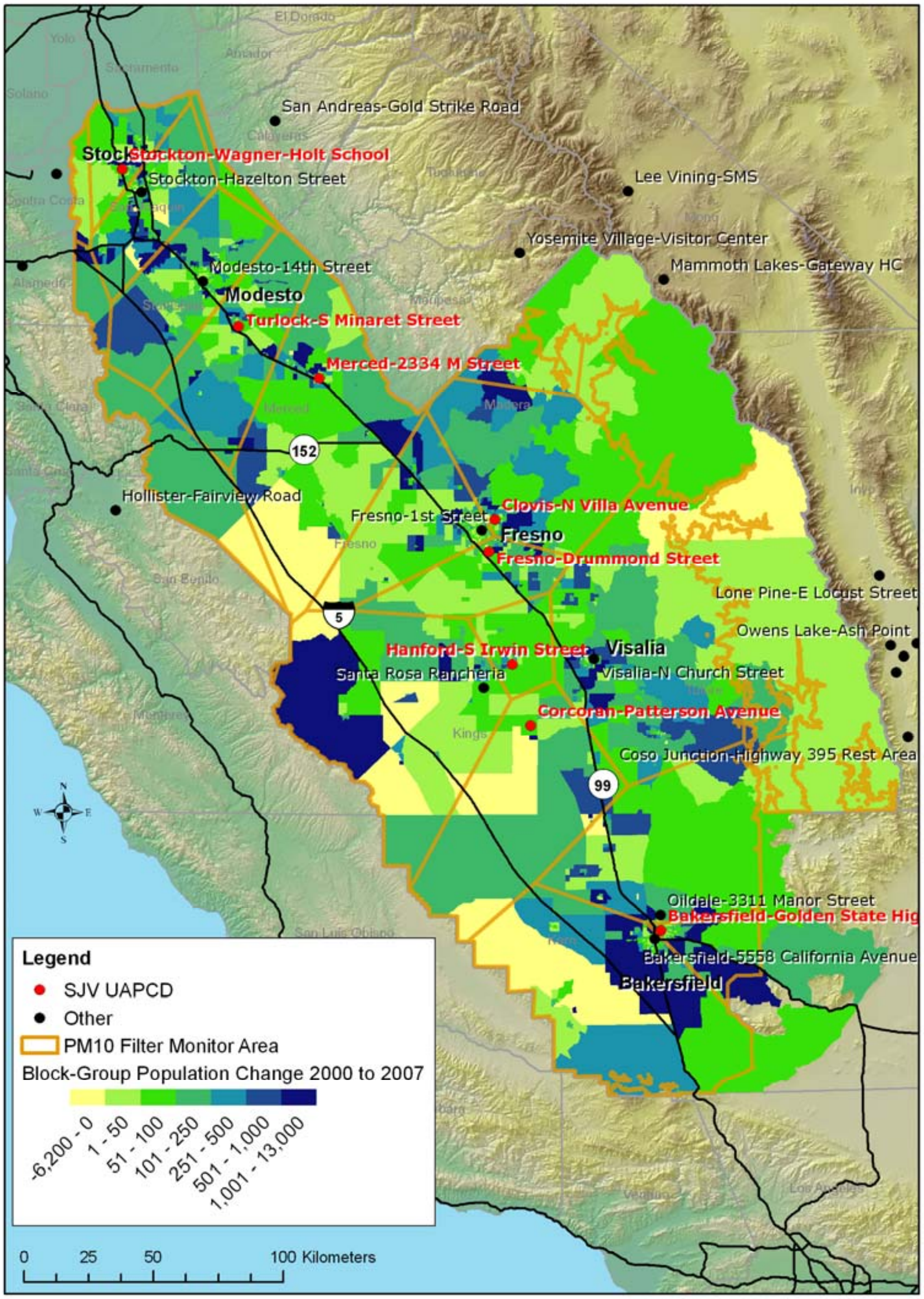
Block-group population change for $PM_{2.5}$-1hr monitor areas, including planned site locations



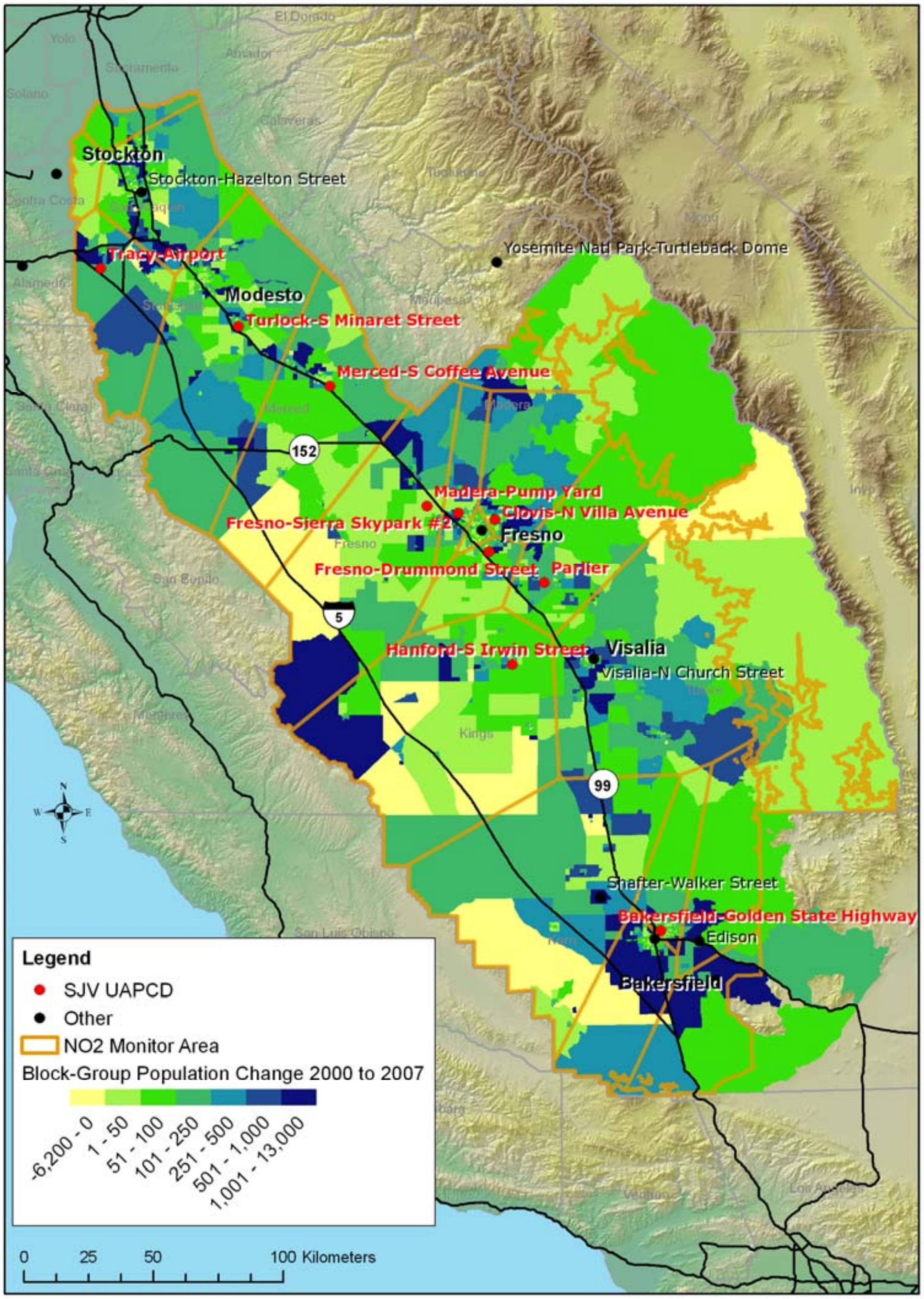
Block-group population change for $PM_{2.5}$-24hr monitor areas



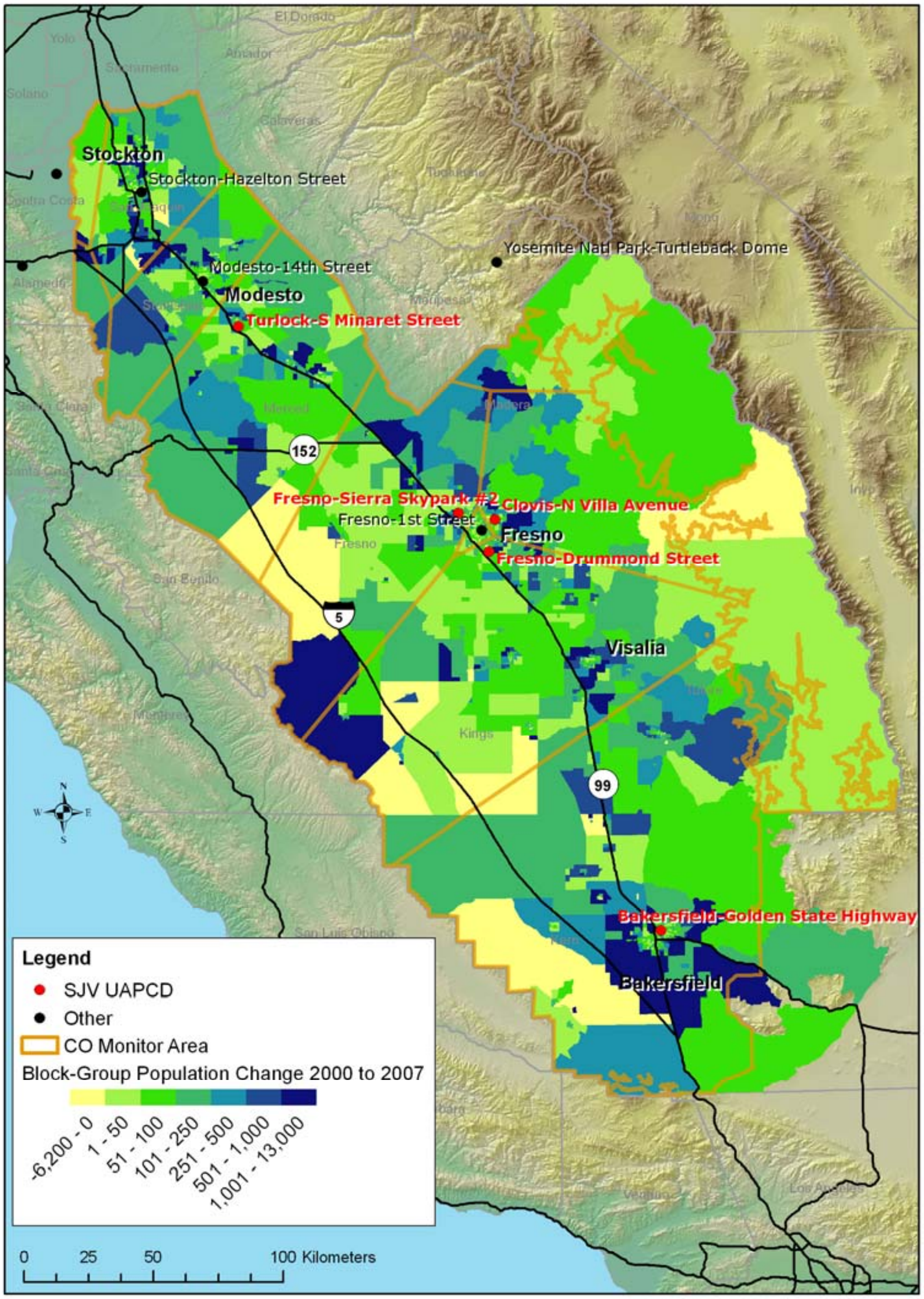
Block-group population change for PM_{10}-1hr monitor areas, including planned site locations



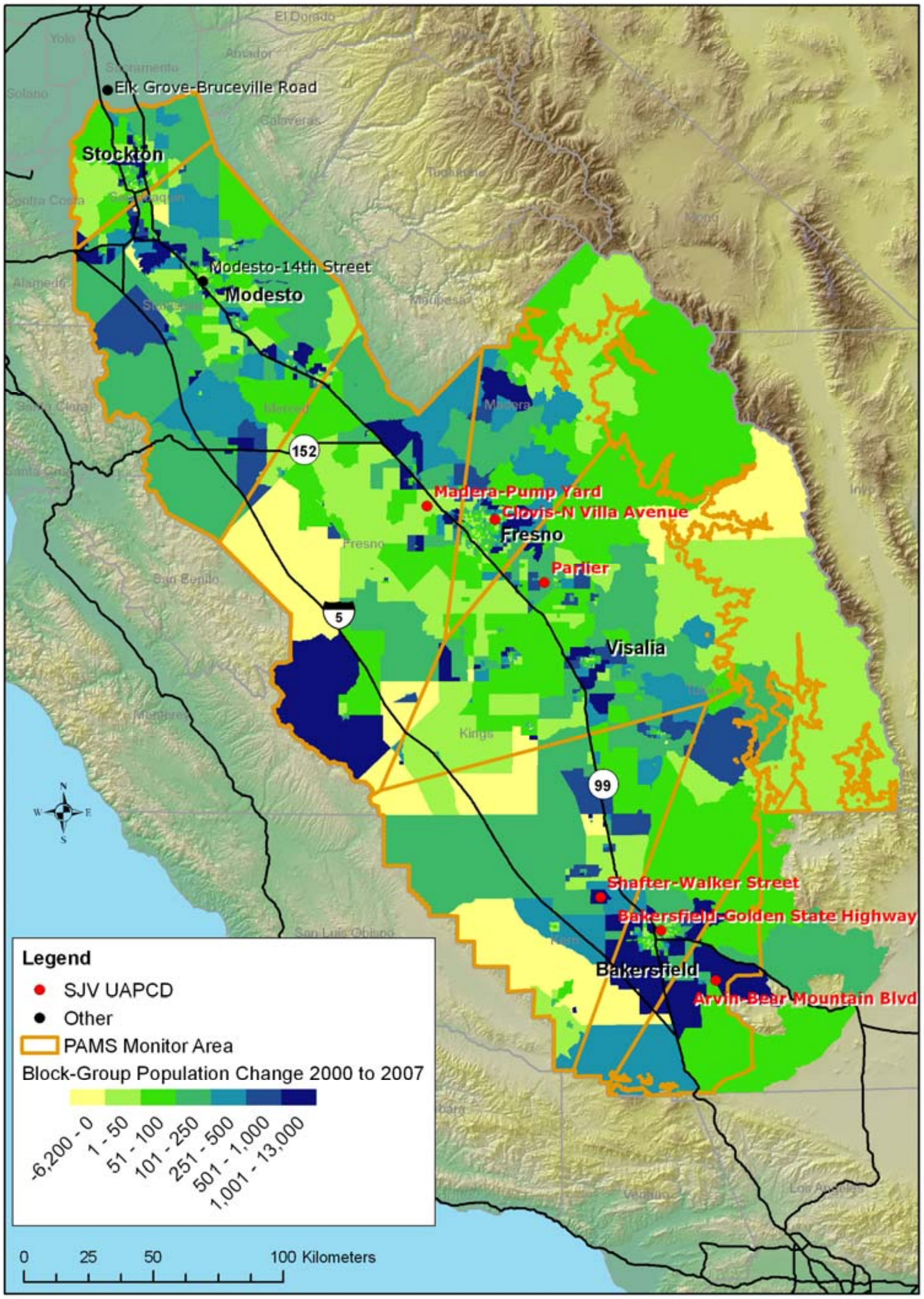
Block-group population change for PM_{10}-24hr monitor areas



Block-group population change for NO_2 monitor areas

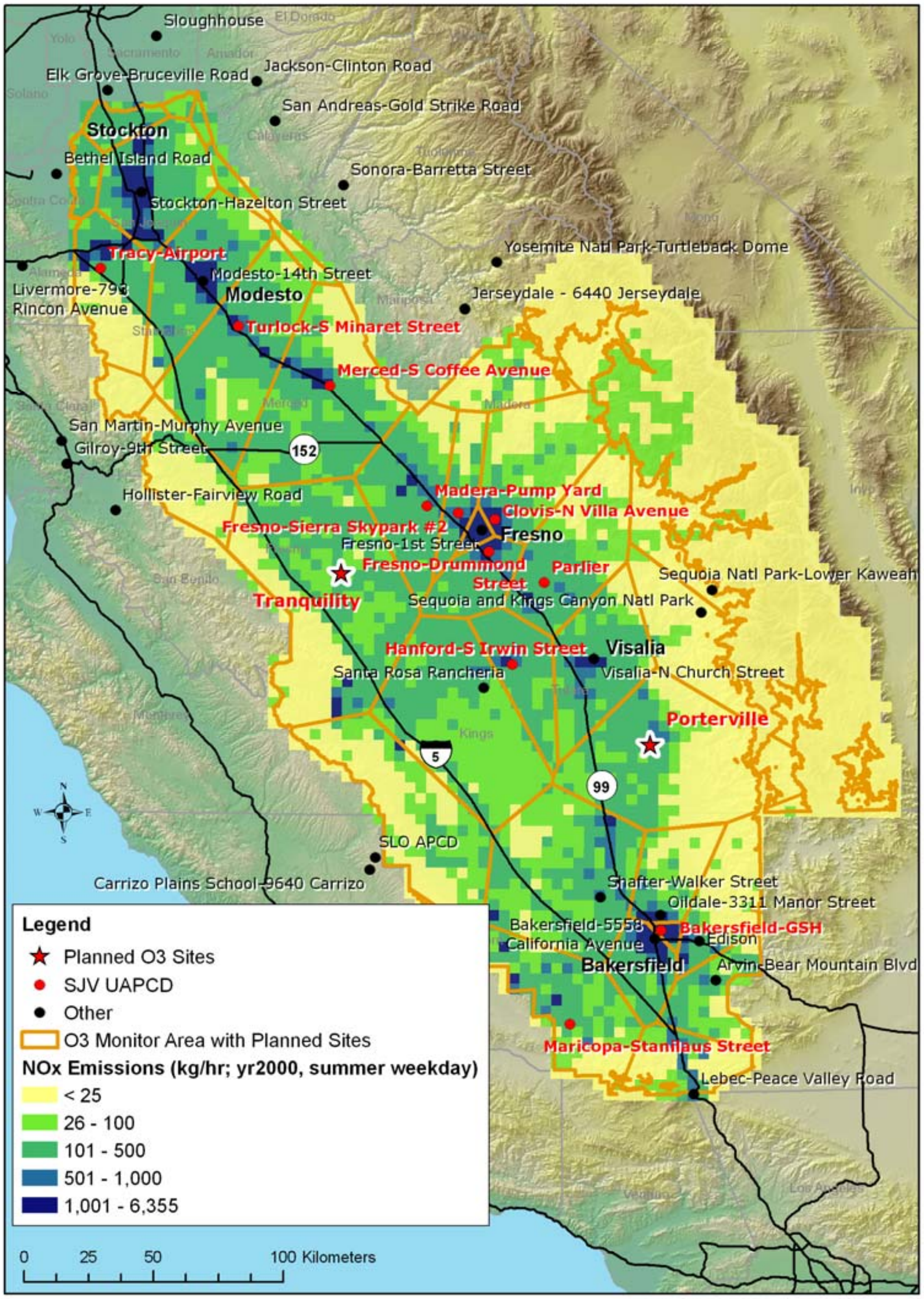


Block-group population change for CO monitor areas

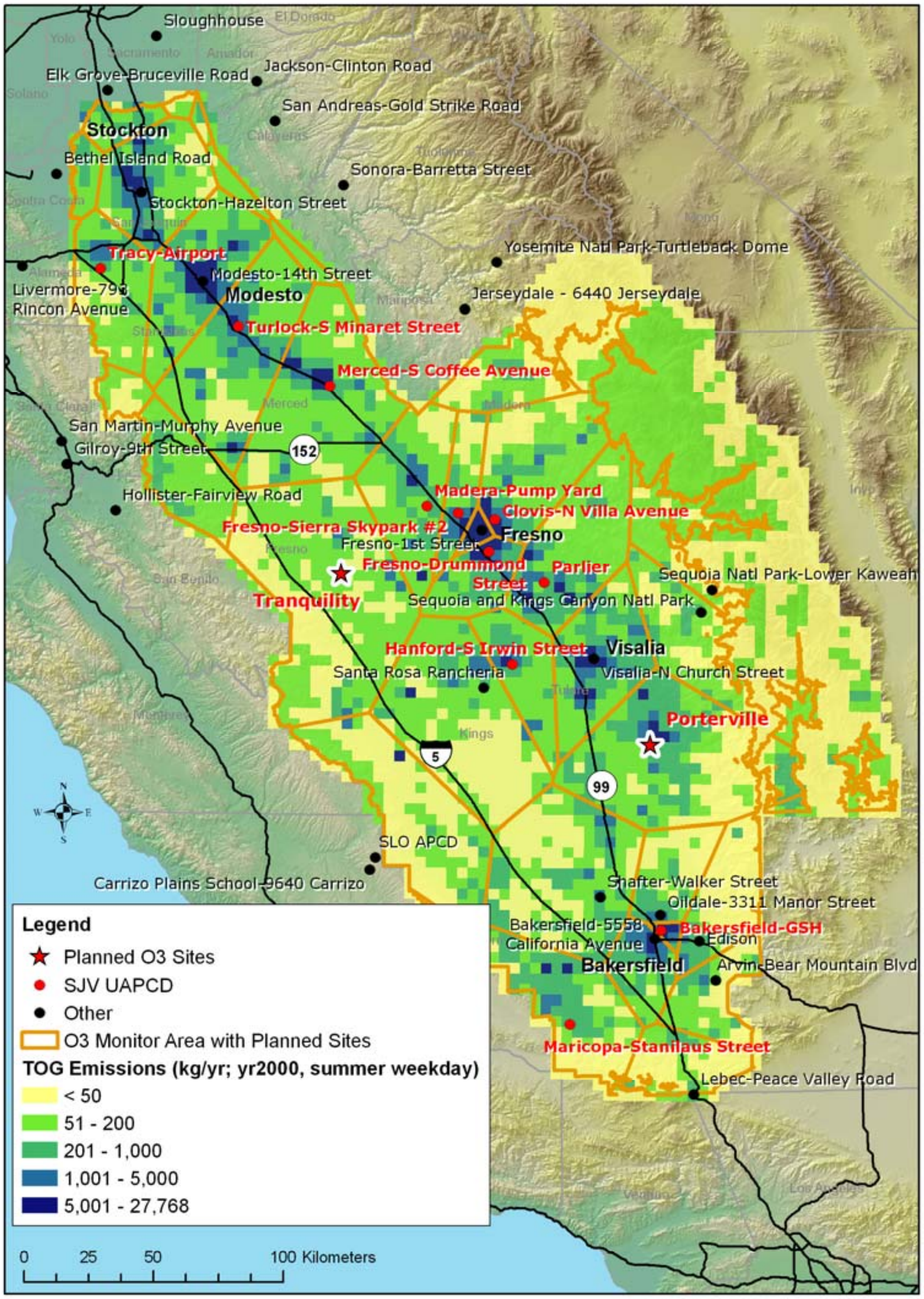


Block-group population change for PAMS monitor areas

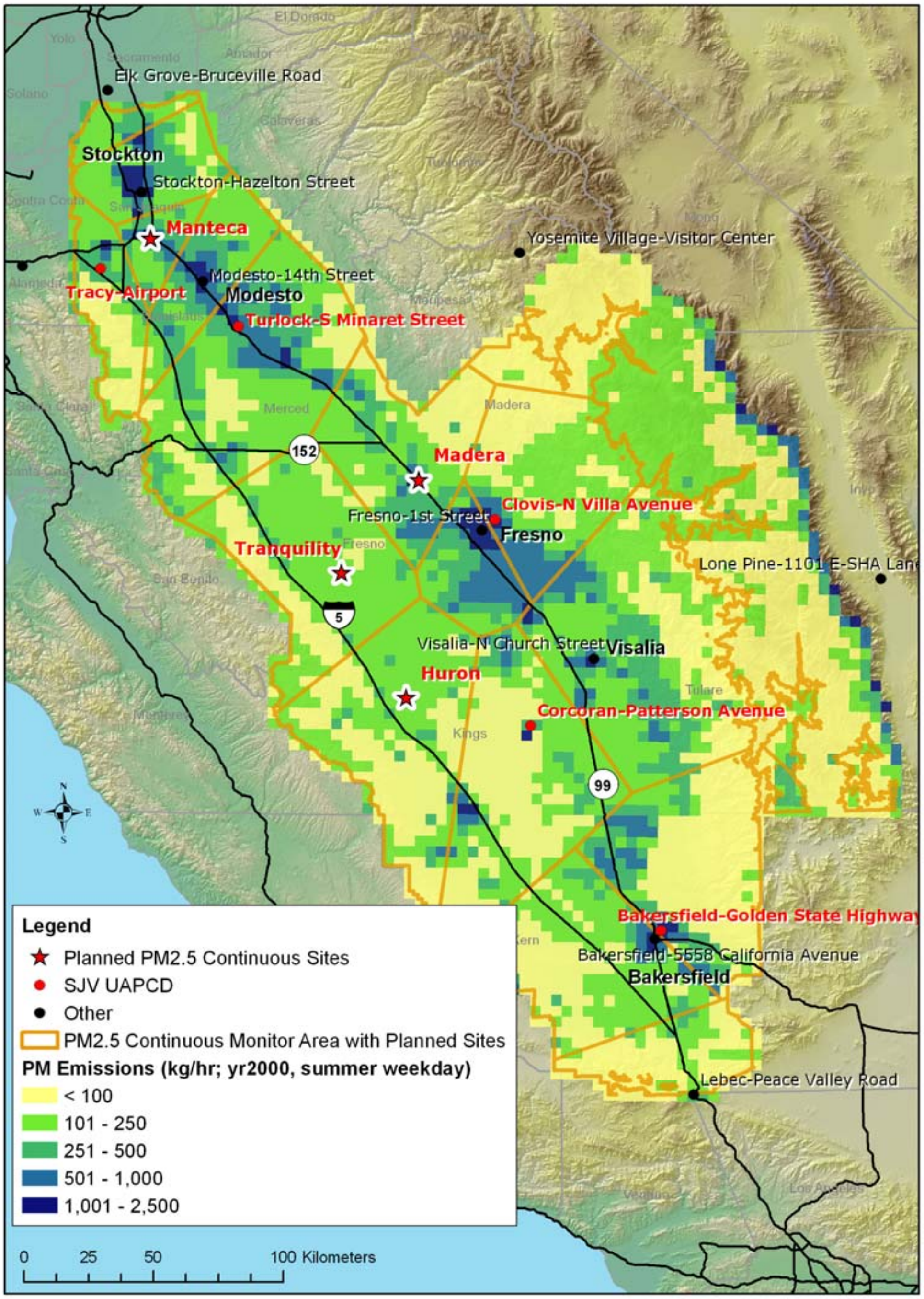
SPATIALLY RESOLVED EMISSIONS MAPS



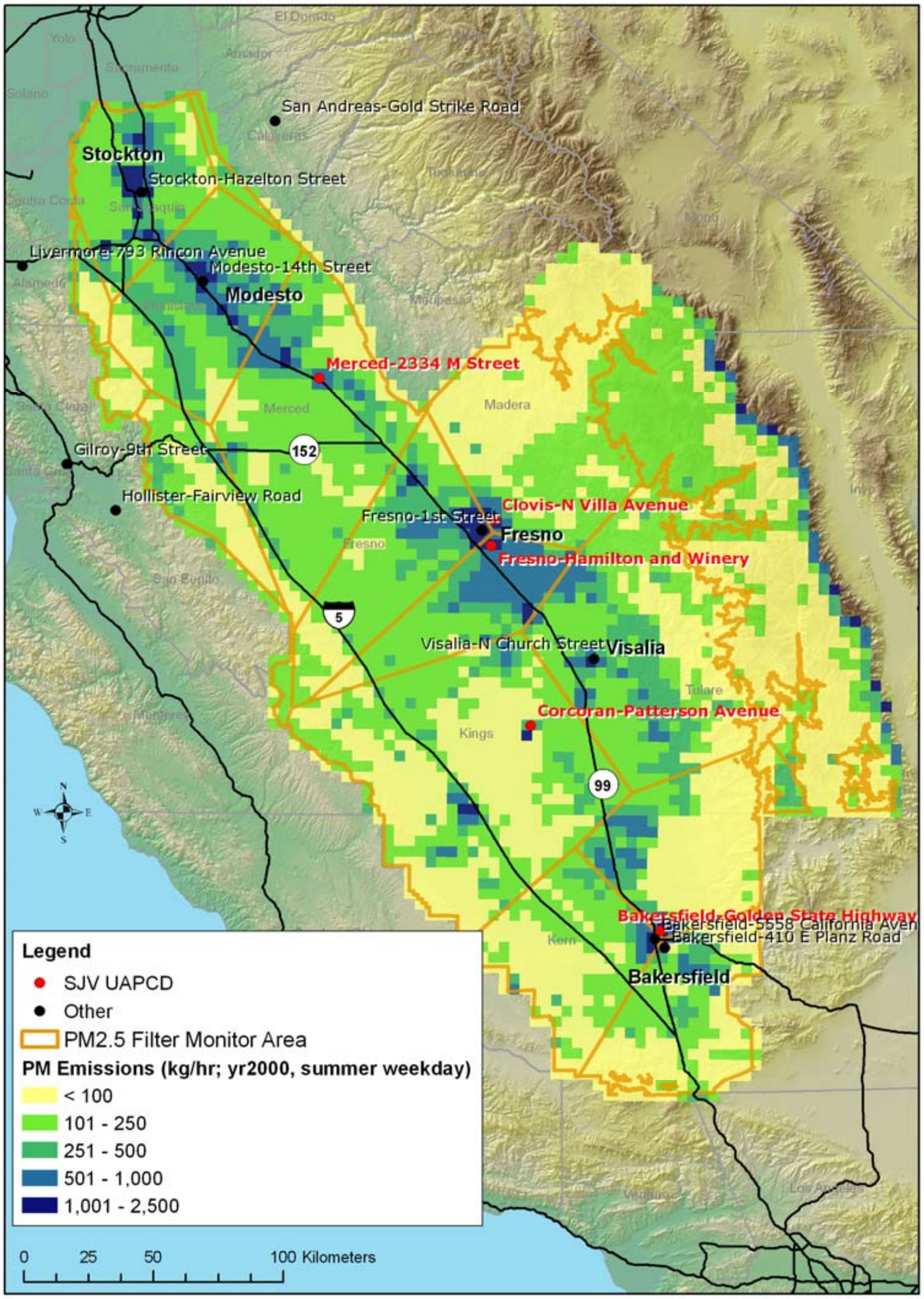
Spatially resolved NO_x emissions served for O_3 monitor areas, including planned site locations



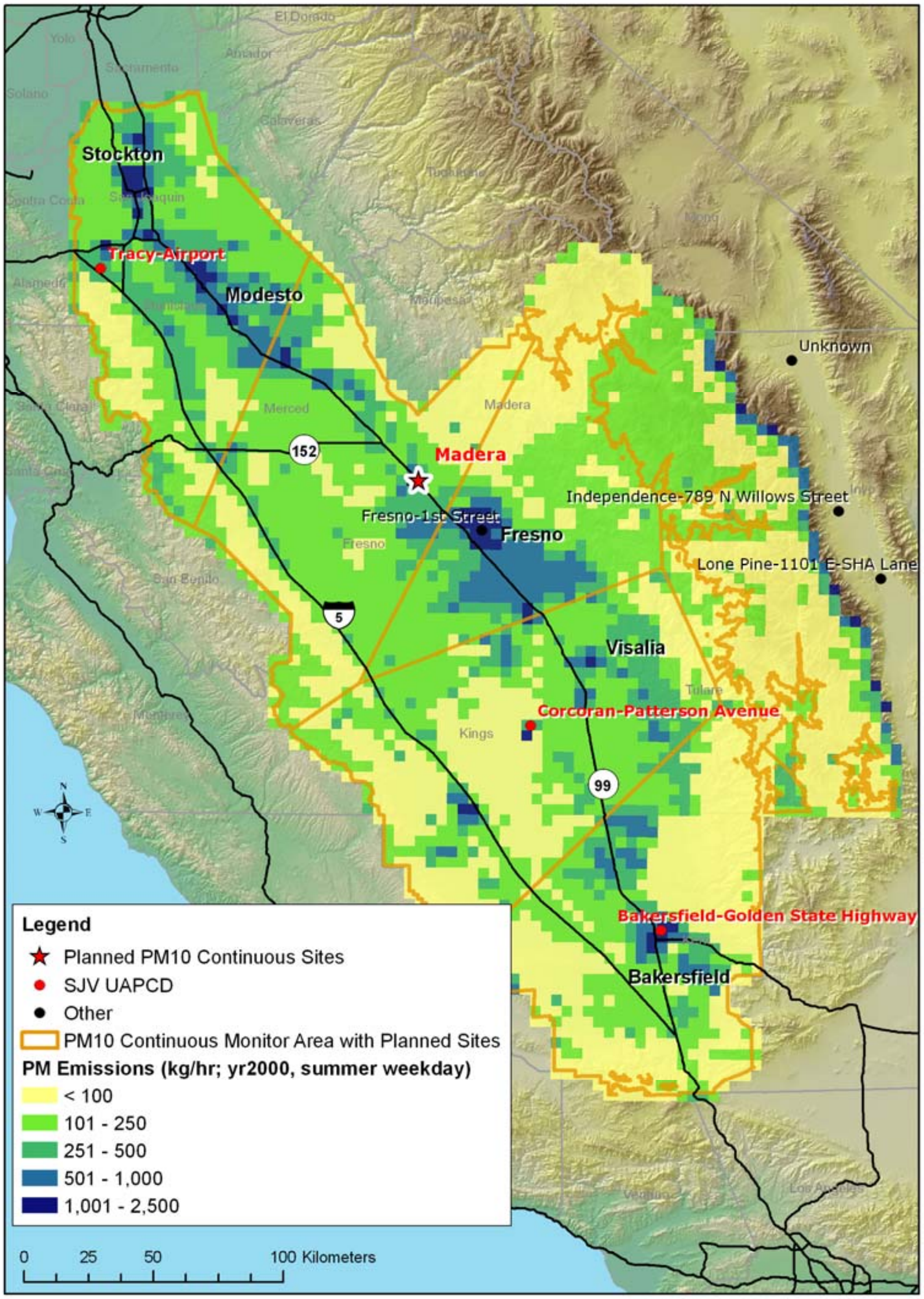
Spatially resolved TOG emissions served for O_3 monitor areas, including planned site locations



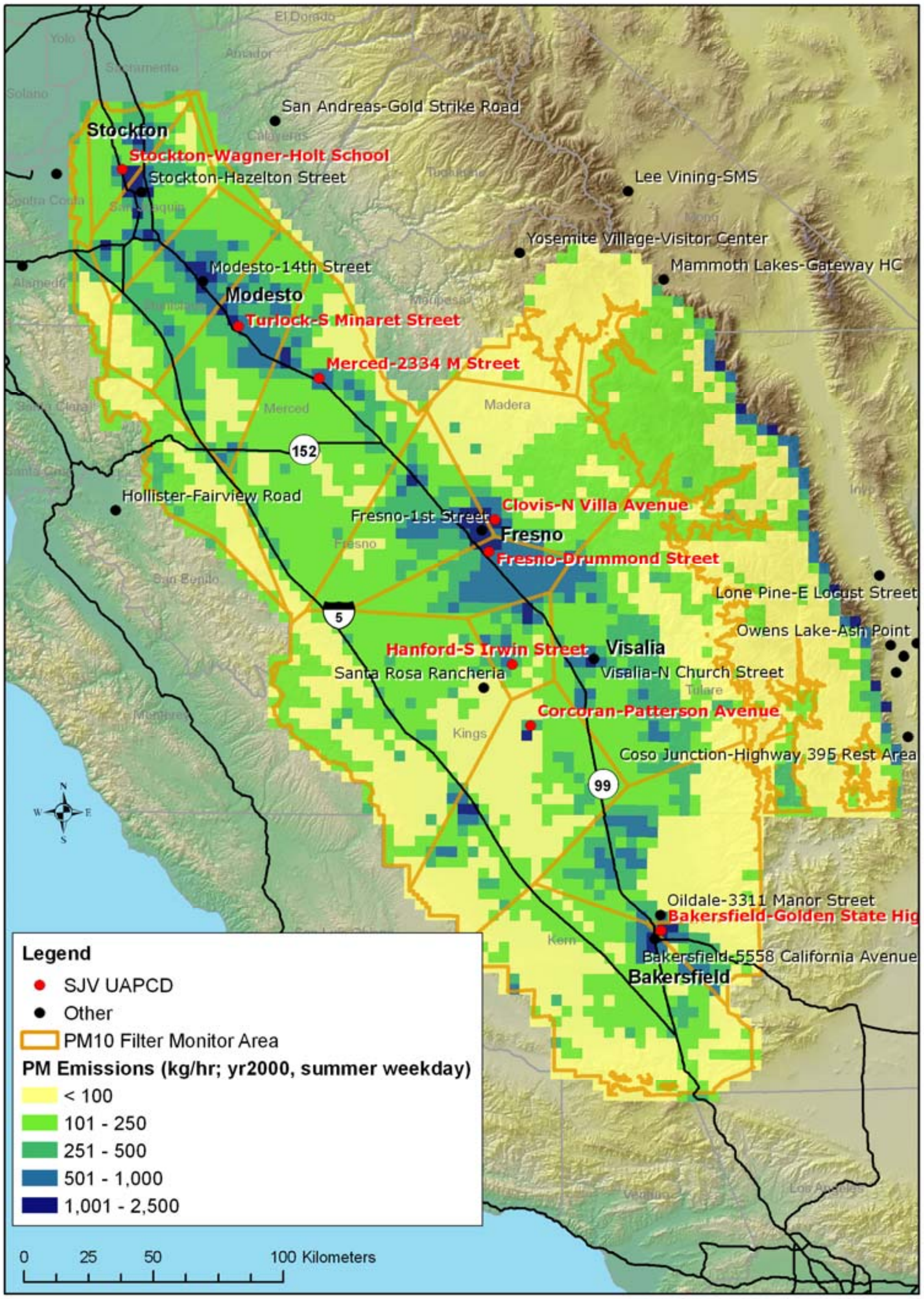
Spatially resolved PM emissions served for $PM_{2.5}$-1hr monitor areas, including planned site locations



Spatially resolved PM emissions served for $PM_{2.5}$-24hr monitor areas



Spatially resolved PM emissions served for PM_{10}-1hr monitor areas, including planned site locations



Spatially resolved PM emissions served for PM_{10}-24hr monitor areas